PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

VOLUME XXIX

EDITED BY THE PUBLICATION COMMITTEE

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THE ENGINEERS' CLUB OF PHILADELPHIA
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OF PHILADELPHIA.

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PAPER NO. 1105.

FAILURE OF AUSTIN DAM.

J. W. LEDOUX.
(Active Member.)
Read October 21, 1911.

THE failure of the dam at Austin, Pennsylvania, on September 30, 1911, affords a sad but immensely valuable lesson to hydraulic engineers. It teaches that in building such structures the first requirement is the absolute safety to human life; the second, that it shall serve its purpose; third, that it shall cost a minimum. Apparently, in this case the ends attained were in reverse order with the last term negative.

It is a principle of humanity that the most valuable lessons are taught and firmly impressed by discovery of disastrous error. Some one has said that no engineer is safe until he has made some serious blunder.

The consequence of the Austin dam failure will probably result in making unduly expensive for the next few decades all similar structures.

The Johnstown flood taught the importance of the spillway for earth dams, while subsequent experiences in the Allegheny Mountains gave specific data which indicated that in small drainage areas of 1 to 10 square miles it is not unreasonable to provide for a flood flow of 400 cubic feet per second per square mile.

The design of a masonry dam, as far as its section is concerned, can be successfully executed by any technically trained boy just out of college. It is only necessary to be familiar with the simple principles of statics, the resolution of forces, and a few empirical rules. To resist overturning he makes the section such that the resultant of the water pressure and the weight of the assumed section of unit thickness will fall within that section at every point. If this condition is fulfilled, under the most severe conditions of exterior load that will ever take place, the dam will not overturn unless the masonry or rock crushes. To avoid this, as well as to provide for a factor of safety, the shape is made such that the resultant falls at all depths within the middle third of the section. In making this calculation it is considered conservative to allow for possible upward pressure. Under the worst conditions this might amount to half the hydrostatic pressure, but no one allows for more than a third, which is even then considered ultraconservative.

It is sometimes considered proper to calculate the safety of the structure against sliding, and for that purpose he assumes the entire horizontal pressure of the water resisted by the weight of the dam, less the assumed upward pressure, which net weight is multiplied by the coefficient of friction between masonry and rock, using about 0.7. In both cases a factor of safety of two is considered good practice. The effect of sliding, however, can be eliminated by carrying the structure down into the rock ledge a sufficient distance to effectually prevent sliding.

Theoretically, the top thickness may be zero, but when the effect of unequal strains, frost, and the possible blow from a log, or tree, or ice thrust is considered, 4 feet is none too much, and for a large dam 6 feet is better.

Now, when all these requirements are fulfilled, the pure mathematics portion of the work is done, but the real difficulties are yet to come.

The material upon which the dam is to be founded must be considered. If the foundation is not excavated deep enough the structure will fail, and if it is taken down too deep the cost will be prohibitive, and within these two extremes the engineer has abundant opportunity to tax his judgment to the utmost. The author remembers an excavation for a masonry dam in the South. The bottom looked good and solid, gneissic rock at a depth of about 15 feet, but a series of drill holes revealed a large cavern at a depth of only a few feet below the excavated surface.

tion was extremely high. In other words, the amount of concrete was double that of excavation. Compare this with a few of the large dams of which the writer has recently had charge.

Name of Dam	Capacity in Gallons	Masonry, cu. yds.	Excavation cu. yds.
Tub Mill Creek dam, in the Chestnut Ridge, above Bolivar, Pa.	207,000,000	40,986	26,654
North Branch of Conemaugh dam, above Wilmore, Pa.	1,025,000,000	35,972	39,603
Indian Creek dam, nine miles southeast of Connellsville, Pa.	240,000,000	7,840	9,273
Lloydell dam, on South Fork Branch of the Conemaugh, ten miles above South Fork, Pa.	204,000,000	30,148	45,031

All these dams extended down into the rock a great depth. The Tub Mill dam went down to a maximum of 50 odd feet. The North Branch of the Conemaugh, about 40 feet. Indian Creek dam, to a maximum of 20 feet. Lloydell dam to a maximum of 80 feet. As these dams were solidly bedded against the down-stream rock vertical face there was no possibility of their sliding, which was, undoubtedly, the cause of the failure of the Austin dam.

The Austin dam was built of concrete, stated to be mixed in proportions of one, three, and six, and an examination would indicate that it was well built in about the proportions stated.

The sketch, Fig. 7, will show in plan and elevation about how the failure occurred.

According to the article in the Engineering News, the dam contained steel reinforcement uniformly located, but an examination of the fractures will indicate that this was not as shown. In fact, the reinforcement cannot be considered as of any value whatever, and it was unnecessary, except to prevent temperature cracks, or to anchor it to the bottom, but, as for either of these purposes, many times the amount used would be required, it is seen that this reinforcement is of no consequence whatever.

According to the same article, this dam practically failed in January, 1910, and how those responsible for the dam could have assumed that it was safe after that failure is almost inexplicable. The

case is parallel to that of a beam or girder uniformly loaded to such an extent as to cause it to crack in several places. The load being immediately relieved, the beam stands in its weakened condition, and, afterwards, when loaded up to even a greater extent than originally caused the break, final failure must inevitably take place.

It is said that at the time the dam was originally cracked, a hole was dynamited through it which caused the water level to go down, and naturally relieved the pressure. It is also stated that the reservoir had not been filled up again until just before the final failure. The information, which the author obtained second-hand, is that

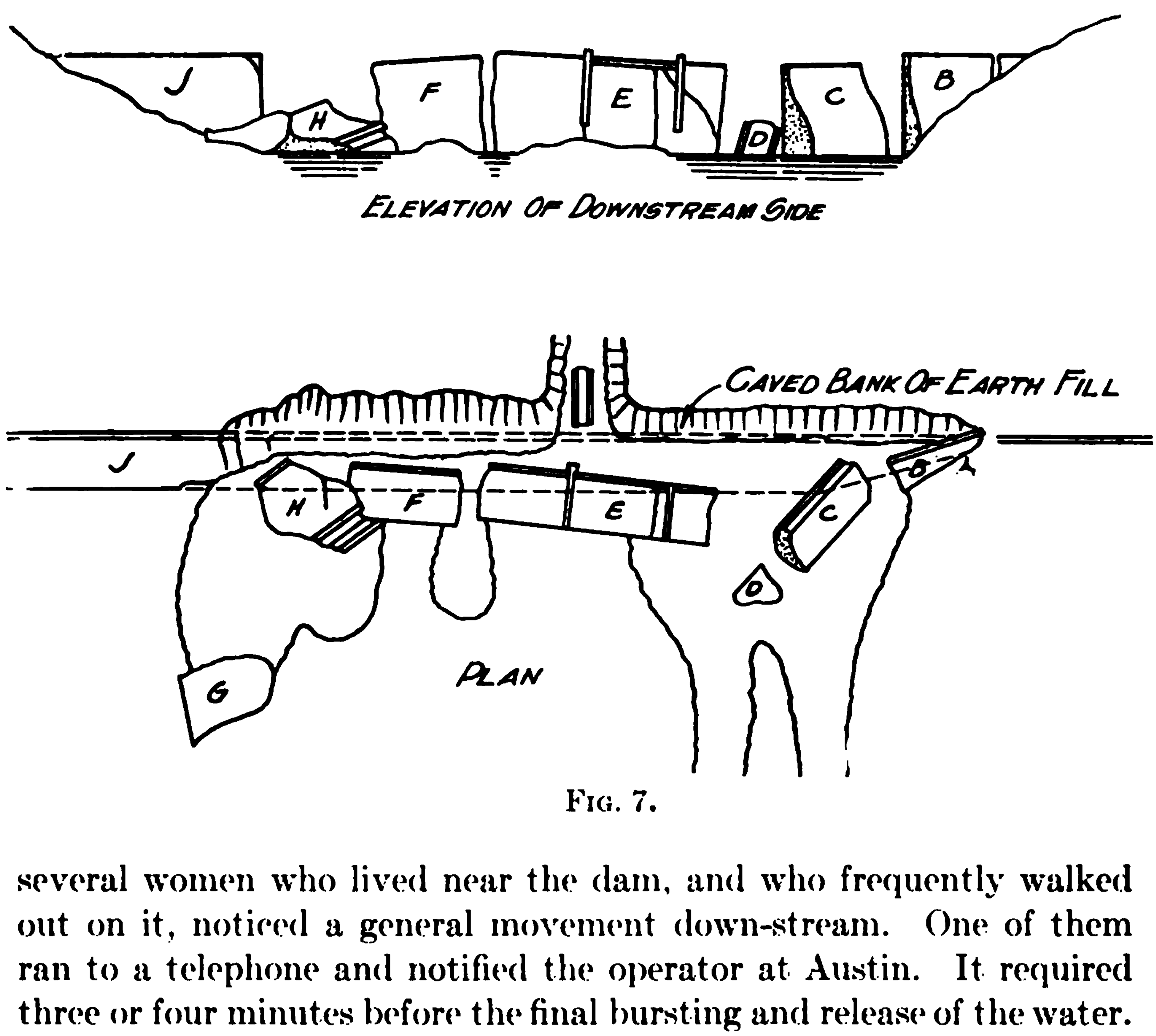

FIG. 7.

several women who lived near the dam, and who frequently walked out on it, noticed a general movement down-stream. One of them ran to a telephone and notified the operator at Austin. It required three or four minutes before the final bursting and release of the water. It is also stated that the wave required about seven minutes to reach the manufacturing plant of the Bayless Pulp and Paper Mill, which was three-quarters of a mile down-stream, and four or five minutes longer to reach the town of Austin, which was a half-mile below the paper mill.

It would seem, from the conditions and the position of the fractured

sections, that the dam must have failed by sliding, because all the large sections stand on their original bases, but at a considerable distance down-stream.

With the exception of two, all the lines of fracture were in existence more than a year ago, and observation showed that the fractures were partly along planes between concrete built at different times. In fact, in nearly all cases such planes could be seen, showing that they represented the lines of least resistance. In some cases these planes were horizontal and one of such planes at the west end of the dam was 30 odd feet long and passed through the entire section. Another plane that could be seen distinctly was several hundred feet long and probably represented the line between the finishing of one period of work and commencing of the next. This could be seen plainly on the down-stream side near the natural ground level. However, none of these fractures could be considered responsible for the weakness or failure of the dam. This was due to some deeper cause, and when the strain became too great, naturally, the breaks would occur along these planes of cleavage, but it must be understood, that if the dam was in other respects perfect, these cleavage planes would not have been a source of weakness. Such cracks may, however, be criticized, because temperature cracks are almost sure to occur at these places, and, therefore, water could leak through the dam, generally, however, in very small quantities. A gravity dam is built on the principle that, if it were sawed through transversely in sections of one or more feet in length, the sections would stand just as safely as if they formed one continuous solid mass. It has been said that this dam was built of boulder concrete, often called cyclopean concrete, but this is not generally true. Most of the dam was composed of concrete, pure and simple, with some boulders near the bottom. However, this is not important.

Now, if the dam failed by sliding, what was the cause? The weight of the concrete is found to be about 135 pounds per cubic foot, and, figuring the weight of the dam and its coefficient of friction against the rock underneath, it is found that there would not be anywhere near sufficient water pressure to slide the dam on the surface of the rock; and, judging from its appearance, the engineer or men in charge of the construction of the dam must have taken pains to see that the bottom of the dam was in intimate contact with solid rock surface. It is, therefore, entirely unlikely that sufficient water could percolate between the bottom of the dam and the rock to exert a

the investigation, to be due to erosion by constantly falling water against the comparatively soft rock under the down-stream toe, this erosion having gone so far back under the dam as to make the structure unstable. Others have stated that the rock slid on itself causing the dam to fail by sliding in the manner above stated. With this possible exception the cause of the failure of the Austin, Pennsylvania, dam seems to be unique, and, therefore, the judgment of the engineer who was in charge of the work at the time the excavation was completed might not be severely censured in view of the accumulated knowledge and state of the art up to that date. It must be remembered that he was working for a corporation who desired to

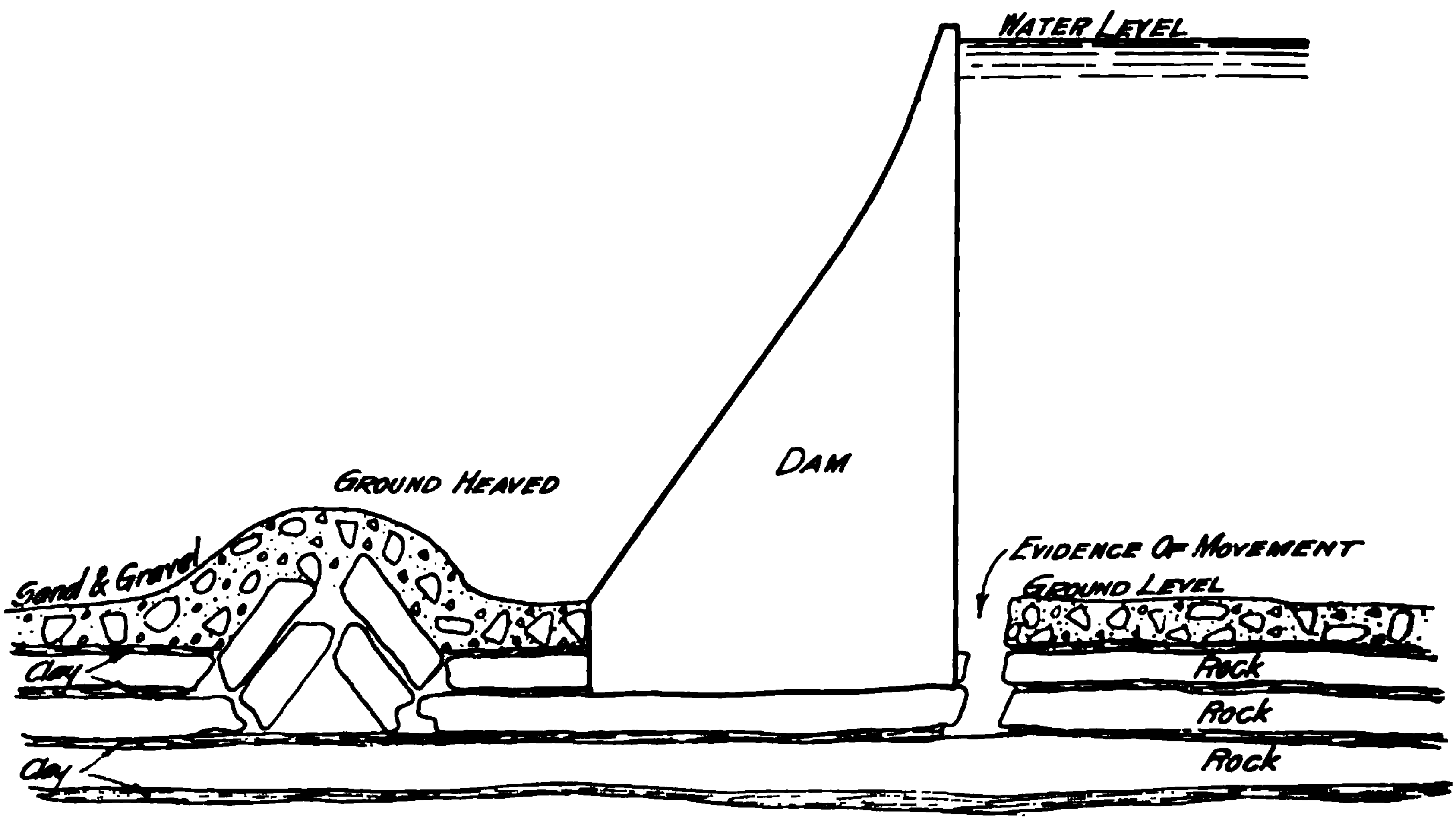

FIG. 8.

build this dam at the lowest possible cost consistent with safety. The engineer saw the surface of the rock as it was exposed to view, and found that it was clean and hard, and certainly possessed sufficient bearing power to withstand the downward pressure. He was also positive that the coefficient of friction between the concrete and this rock would be sufficient to prevent sliding. He had probably sunk test holes enough to indicate that the character of the rock for a considerable distance below the surface was not any more solid or suitable for a foundation. Therefore, he saw no reason to go deeper, or to believe that the dam would overturn or slide on this rock surface. His reasoning up to that point was absolutely sound, and

sure acting upward against the dam, it would probably have been worth while to sink a deep cut-off trench on the up-stream side of the concrete masonry, and to a depth of 15 or more feet. This trench should have been filled solidly with concrete which should have extended slightly under the dam.

All this could have been obviated, originally, by carrying the dam down 5 or 10 feet deeper.

There is one feature of the construction of the Austin dam that is particularly noticeable and which was mentioned earlier in this paper. The down-stream slope, in all cases, ends at a very short distance below the natural surface of the ground, which would be perfectly justifiable, if the natural ground were solid rock high in resisting power; but, it would certainly not be justifiable when the material is sand, clay and gravel as in this case. An examination of the diagram of the resolution of forces (Fig. 9) shows that the resultant comes within the middle third at all points above the intersection of the slope with the vertical down-stream face; but, below this point the resultant falls considerably beyond the middle third. However, this analysis is not of great importance in view of the fact that the dam did not fail by overturning but by sliding.

As a general proposition, engineers designing masonry dams are not required to give much consideration to the danger of sliding. In the great majority of cases it is necessary, for other reasons, to go to a depth considerably below the rock surface, and this, by proper construction, can be made a bulkhead to resist the sliding of the dam.

From the calculations given above it will be seen that the effect of possible upward pressure was not considered. Neither is it average practice to allow for this upward pressure which, theoretically, might reach a maximum of half the hydrostatic pressure acting upward against the entire base of the dam. The most conservative practice assumes two-thirds of this hydrostatic pressure at the up-stream toe and zero at the down-stream toe. The average pressure would then be one-third of the hydrostatic pressure, and if the forces are as assumed, the resultant of this upward pressure would act at a point distant from the up-stream toe equal to one-third of the base. But as there are a large number of important dams standing safely today, whose section does not take this into account, and which would fail if the upward pressure acted according to this theory, it is evident that it is not by any means a certainty; but, hereafter, no doubt, it will be allowed for in all important structures. The danger of

Fig. 9.

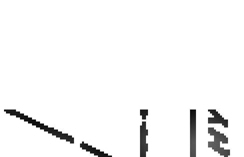

Fig. 9.

upward pressure, however, can be obviated by a not very difficult expedient, and without increasing the section of the dam, in the following manner: It is always advisable to found the up-stream toe on a cut-off wall, say 4 or 8 feet thick, and extending down a considerable depth. When this is constructed it is incorporated with the rest of the masonry and forms a very effective barrier against leakage. If this wall is depended upon for water-tightness, the intersection between the remaining part of the bottom of the dam and the rock can be made porous. For instance, the first 6 inches or more of the bottom can be built in the form of almost a dry wall, and, of course, this would save considerable expense over building the entire section large enough to withstand the upward pressure.

DISCUSSION.

Manton E. Hibbs.—As we have discussed the dam from its technical and mathematical points there is one question we ought to look at aside from that of engineering, and that is, the safety of the people in the vicinity of the dam.

I believe there should be somebody in the State of Pennsylvania to place a check, not really upon the safety of the dams themselves, but the safety of dams with regard to the people they affect. For example, take the case of a river whose natural course is changed, dammed up, and made dangerous by a corporation. Shall the corporation be allowed to do as it pleases, or shall it be compelled to protect the people? When it comes to a question of money-making you will find the safety of the people gets small consideration, and I believe there should be some check upon the owner and the engineer. This will not retard the work of the engineer or owner in any way and the most efficient will win out in the end.

I am not criticizing so much the engineer who designed the dam with regard to the loss of life, but, merely, to look at the matter of safe construction and its responsibilities. The responsibility rests, first, with the engineer who designed the dam, then with the people who employed him, and the contractor who superintended the construction. Finally, the State should assume responsibility. It is only through the harmonious relations of these different elements that safety in a structure can be insured.

Edwin F. Smith.—I cannot add much to what Mr. Ledoux has told us about the construction of dams. There is one thing, however, that impresses me and it comes to my mind from time to time as horrible accidents like this happen and it is this: that engineers should be more careful about foundations when building such structures. It is not sufficient to start the foundation of either a masonry dam or a timber dam when we touch rock; it is not sufficient to put down drill holes to ascertain what is the character of that rock; it is better to sink shafts and go down to the bottom until we find we have solid rock and a good foundation. A dam, such as that at Austin, should not be built upon rock that is in alternate layers with clay, or even hard pan, between the layers. We should not build foundations for a concrete dam on anything but bed-rock, rock that is

Legislation should cover not only the design and construction of dams, but provision for knowledge of the care in operation, for neglect, carelessness, or unappreciation of conditions may seriously jeopardize an otherwise satisfactory structure. Such an example was given us 22 years ago by the Johnstown disaster, in which the failure of a dam was a contributing cause, yet this structure had stood for a half century and showed no signs of weakening until abused. The removal of drain pipes and placing a fish screen across the spillway greatly reduced the facilities for wasting excess, and the improper filling in of the pipe trenches, left a depression. With extreme rain-fall conditions and resultant clogging of the screen by débris the outlet was insufficient and the further weakening of the embankment as the water rose, by turning a furrow to make additional height, permitted the water to spill over and cut the entire embankment when overflow had once begun.

The growth of population and the desire for uncontaminated sources of water supply require more and larger dams and reservoirs, sometimes of considerable depth. The development of water power is continually growing, in which the maximum practicable fall is desired, while seasonal variations in precipitation create a demand for storage basins to augment the stream flow at periods of low discharge. The quantity of water required to increase the available power for a number of days, perhaps for months, demands storage facilities often of enormous capacity; quantities that make appear insignificant the contents of the Austin dam, which did not exceed one day's supply for the city of Philadelphia.

Mention was made this evening of a printed statement that the public was losing confidence in engineering, a statement which seems best combatted by facts, viz., the immediate acceptance by the people of engineering work, such as the rental of office space in extremely high buildings, or the utilization of river tunnels, etc. And although the Austin and Johnstown dams are not the only failures, the others have fortunately done little or no damage; yet their total is a very small proportion of the number of existing structures; a fact which can assure the public.

In the matter of construction I believe that there should be some advocation by the profession for authority to the engineer. In many cases the authority is divided between the engineer and his clients, but it is not difficult to guess where the responsibility of any fault is placed. Or, in another instance, it is manifestly unfair to both parties, as well as to the public and the profession, that a well planned design should be taken from an engineer and built according to the idea of some one else who may or may not be fitted. For I believe that an engineer given full authority would willingly accept the responsibility.

Public demand for legislation is justified in view of the fact that many existing dams had been built with no approval beyond a charter right, and under no compulsion of stability of design, character and quality of material, and construction or care in operation. The technical publications as well as some engineers have been advocates of governmental control. Any legislation should be both protective and fair, and of such character as to appeal to the public, not only now but at other times. And with a trend of sentiment in this direction, the engineering profession should well consider this matter, and suggest such action as it deems advisable and equitable.

John C. Trautwine, Jr.—There would seem to be no question as to the

believe this will accomplish very much unless we can get a higher class of men to act as our legislators, governors, etc., and a greater number of competent and experienced men willing to act upon our public commissions. We now have a number of good laws looking to the protection of the public morals, sworn officers of the Court, and an efficient police force to enforce them; still all of us realize what a farce the enforcement of these laws becomes at times.

It is generally conceded, I believe, that the Austin, Pennsylvania, dam failed on account of defective foundations and under the proposed legislation it would be the duty of the one appointed to pass not only upon the design, but also upon the foundations and methods of construction of any proposed dam. Let us take a concrete case:

John Doe, desiring to construct a dam, will submit a set of drawings to the State for its approval; should the design not be a proper one the State will insist upon changes being made before it will grant its approval. The next step is the construction, and here again, the State steps in and passes upon foundations, etc., insisting in all cases of doubt upon its view being carried out. The net result is that the State, through its appointed officers, becomes virtually John Doe's engineer from the time the plans are submitted to the final and successful completion of the work. I believe that we, as members of the Engineers' Club, do not want to see this.

Referring to the editorial in this week's Engineering Record I agree with Mr. Smith that good engineering is not open to criticism and should not be criticized. Nevertheless, a failure such as that at Austin reflects on all engineering and the good suffer with the bad. The evidence of this is seen in the agitation by the inhabitants of the valley of the Croton River for an investigation of the new Croton dam. Another case is that of the public water supply for Columbus, Ohio. Columbus, I understand, several years ago, constructed a dam for impounding a new water supply, but on account of financial and other reasons the dam was never completed to its designed height. Now that additional water is required, it is proposed to complete the dam, but the citizens of Columbus have overruled their engineers, who are men of high professional rank, and have decided that, in view of the Austin failure, they will not complete their dam.

The Engineering News in an editorial, issue of October 5th, states that "the lesson of Johnstown fell upon deaf ears." I do not think the statement is warranted. The Conemaugh dam failed by overtopping and erosion, whereas the Austin dam failed primarily from faulty foundations, which is an entirely different condition.

The week following the failure of the Austin dam there were two failures in Wisconsin. These dams were composed of masonry spillways flanked on each side with earthen embankments with core walls. The cause of the failures was the overtopping of the earthen embankments due to inadequacy of the spillways; in this connection, I think engineers, as a rule, make a great mistake. Let us for a moment consider the spillways:

The upper, or Dell's dam, had a masonry section about 285 feet long by 29 feet high which acted as a spillway section. The spillway proper was 260 feet long and was designed to carry a depth of water of $5\frac{1}{2}$ feet; and, in addition, there were four 4 feet by 5 feet sluice gates through the dam. The remainder of the dam was of earthen embankment approximately 500 feet long, with a

for the design and would be criticized, at once called in Mr. Wegemann who is considered an authority on designs of dams. Mr. Wegemann made a report to Mr. Hatton, recommending certain changes, which, in his opinion, would make the dam safe. I feel sure that Mr. Hatton incorporated Mr. Wegemann's report, with one of his own to the Bayless Pulp and Paper Company, and in this action he did what any of us would have done to have corrected a piece of defective work. Why the Bayless Pulp and Paper Company did not carry out these recommendations, or at least see to it that the dam was not filled again, is inexplicable.

I am not opposing State control, for I think some form of State control of this class of structures is inevitable, but I am opposed to it unless it is more wisely administered than heretofore; and, in this connection, I want to bring out the fact that the State does not give sufficient reward in the way of salaries to induce men of ability to enter its employ. Public officers do not receive sufficient salaries to induce men to make a study of political government, and men who have the executive ability to act as the governor of a State such as Pennsylvania, can earn salaries many times larger as executive heads of the great corporations; and in addition, they are not subjected to the criticism and gibes of the public.

Massachusetts and Colorado have State supervision and I would add that both of these States have had failures of dams within the past few years.

Wm. Copeland Furber.—I want to endorse the remarks of Mr. Hibbs regarding State control. I think it should be accepted without argument that anything of a public or semi-public nature affecting public interests in any way should be supervised by some public officer, and whether the officer is efficient or not has nothing to do with this principle. The responsibility for the efficiency of the officer rests entirely where it belongs, on the shoulders of the people.

I do not know what condition our cities would be in today if there was no municipal bureau of building construction and inspection, and if the owners were allowed to exercise their own ideas of economy in building construction, and in this connection I would say that it is my belief that the powers of the municipal bureau should be increased rather than diminished in such matters.

I do not think that the engineer or the architect should ever fear State control. On the contrary, I think he will find the State or Municipal department for supervision of construction will back him up when he should be backed up, and will prove a tower of strength in circumstances where greed, stupidity or lack of intelligence on the part of the owner would produce disastrous results.

PAPER NO. 1106.

THE PRESENT ACTIVITIES OF THE COAST AND GEODETIC SURVEY.

O. H. TITTMANN.
(VISITOR.)

Read November 4, 1911.

THERE are various reasons why the head of the Coast and Geodetic Survey should be particularly glad to speak to an association of his colleagues in the engineering profession in Philadelphia. Philadelphia stands in a certain maternal relationship to the Coast Survey for, when the question of organizing a survey was up, the government turned to members of the American Philosophical Society for counsel and guidance. In response to the circular of the Secretary of the Treasury, calling for plans for the conduct of a survey, thirteen plans were submitted. These were fortunately referred to the then Vice-president of the American Philosophical Society, as Chairman of the Committee, to decide on the adoption of the best plan. The Committee endorsed the scientific methods proposed by Mr. Hassler who became the first Superintendent of the Survey.

It was a good example to set, but one which the government has not always pursued, to have the fundamental principles on which a work of applied science should be done, submitted to scientific men for consideration. To engineers it may seem as though no other way could have been chosen, than the one that prescribed a trigonometric survey as the basis of an extended survey, but as a matter of fact other methods were proposed. These things occurred in 1807, from which date it is seen that this Bureau is old in years, but facts will show that it is young in spirit, and strives to march in the van of progress, to lead where it can, and to follow only where it must. When the plans for a survey were made the Coast of the United States extended from Maine to Florida. The Floridas, much of the Gulf Coast, the Pacific Coast and Alaska were geographical conceptions outside of what is now the United States. At the present time the work of the Survey has been extended to the Philippines, the Hawaiian Islands, and other islands under the jurisdiction of the United States.

In brief language the following extract, from an official publication, describes the duties of the Survey:

"The Coast and Geodetic Survey is charged with the survey of the coasts of the United States, and coasts under the jurisdiction thereof, and the publication of charts covering said coasts. This includes base measure, triangulation, topography, and hydrography along said coasts; the survey of rivers to the head of tide-water or ship navigation; deep-sea soundings, temperature, and current observations along said coasts and throughout the Gulf and Japan streams; magnetic observations and researches, and the publication of maps, showing the variations of terrestrial magnetism; gravity research; determination of heights; the determination of geographic positions by astronomic observations for latitude, longitude, and azimuth, and by triangulation, to furnish reference points for State surveys.

"The results obtained are published in annual reports, and in special publications; charts upon various scales, including sailing charts, general charts of the coast, and harbor charts; tide tables issued annually, in advance; Coast Pilots, with sailing directions covering the navigable waters; Notices to Mariners, issued monthly and containing current information necessary for safe navigation; catalogues of charts and publications, and such other special publications as may be required to carry out the organic law governing the Survey."

It is because of the vastness of the subject that this paper is intended to touch upon present progress, conditions, and problems only and much that would be of interest and importance must be omitted.

The principal business of the Survey is making charts of the coasts. If there were no changes in the depth of channels, if the artificial aids to navigation remained fixed and unchanged, if the aspect of the shores from the navigator's viewpoint remained the same, if the draft of vessels remained the same, if the variation of the compass remained the same, if, in short, things were not as they are on this changing globe or the world were commercially fossilized, a survey once made would last forever. The actual facts are different.

Time was when it was a matter of small concern what dangers to navigation might lurk at a depth of more than 20 feet, but with the increased size and draft of vessels and their enormous cost, a revision and reëxamination of much of the old hydrography by new methods has become necessary. The channel sweep and wire drag now supplement the lead. After these new appliances have swept the bottom the Survey may look with equanimity on the evolutions of ten-million dollar battleships in our waters.

With every new chart that is published the Office assumes the respon-

the triangulation has been referred to Clarke's spheroid on which this particular point has a definite position.

Not only the Coast and Geodetic Survey triangulation, but that of the Lake Survey also, has been referred to this datum and wherever the topographic work of the Geological Survey has been connected with the triangulation of the Coast and Geodetic Survey it is equally referable to this datum. In this way has been achieved a homogeneous system of geographical coördinates for the vast domain of the United States, and it is not unlikely that Canada and Mexico will continue the same system.

It is not necessary to point out to engineers the practical value of a trigonometric survey. New uses for it continually arise. Witness the cadastral survey of Greater New York which is based on U. S. triangulation. The Oyster Surveys of the various States utilize the trigonometric points for the delimitation of the oyster-beds. The Coast Artillery is supplied with data which are used for fire control, and, in general, the network of triangulation forms a basis for coordinating all topographic and economic surveys, and thus the work accomplished is forever increasing in value and usefulness.

Among the unforeseen applications was the demonstration of the precise amount of the displacement of the earth's surface, by the San Francisco Earthquake along the fault line, and the extent of the movement at right angles to it.

Until about six years ago the method of deriving the figure and size of the earth from triangulation was to deduce it from measured arcs of parallels and meridians. That is, after the length of a meridional arc or parallel had been measured, the angle which its termini sübtended was astronomically determined. But owing to the irregular distribution of masses on and within the earth's crust the actual direction of the Zenith differed from the geometrical Zenith of the spheroid of reference. This well-known error, called the deflection of the plumb line, was assumed to average out in a large number of arc measurements. At any rate no correction for it was applied.

A great many years ago, Archdeacon Pratt, while studying the pendulum observations made in India, reached the conclusion that wherever there were visible mountain masses such as the Himalayas there was a corresponding defect of mass in the earth beneath, but it was reserved for the Coast and Geodetic Survey to extend and apply this theory in the computation of the size of the earth from arc measurements by introducing into Geodesy what is now known as

The International Geodetic Association.—To make a new epoch in science is no mean achievement; but mention has already been made of the compliment paid to the Americans at the last meeting of the association in London. This association exists by virtue of a formal convention between the great powers of the world. It is an official organization whose object is to promote knowledge of the size and figure of the earth. Canada, the United States, Mexico, and Argentina belong to it. So do Japan and, practically, all the powers of Europe. It is one of the oldest of international scientific associations. The delegates to the meetings report progress, and compare methods and results, and endeavor to strengthen such undertakings as the Cape to Cairo Arc of the Meridian and the junction of the Great Trigonometric Survey of India with the Russian Survey. To carry out this last piece of work the association covets the coöperation of China and hopes that that ancient empire will ultimately join the other powers in the undertaking.

Among the tasks undertaken by the association is the determination of the variation of latitude. For this purpose, it maintains six small observatories in the northern hemisphere, two of which are in this country and are under the direction of the Superintendent of the Coast and Geodetic Survey.

Two years ago the astronomer in charge of the Observatory at Gaithersburg, Md., proposed the construction of a Zenith tube for photographically determining the variation of latitude and, at the author's request, the association gave about $2500 for the purpose. The instrument was constructed in this country, has been mounted, and the preliminary results indicate that a step in advance has been taken by securing a higher degree of accuracy, than was before attainable, with a considerable simplification of methods.

The association meets once in three years and the principal countries in Europe have vied with each other in extending invitations for meeting in their capitals. Although the Coast and Geodetic Survey has taken an honorable part in these meetings it has never had the privilege of extending the hospitality of this country to the association. Mention of this fact is made with the same embarrassment that the author feels in representing a great nation at such meetings, and having to maintain silence when the different nations of Europe are competing for the place of meeting.

The Geodetic Level.—Fig. 2 shows a picture of the leveling instrument, developed in the Coast Survey, with which nearly all engineers

Trigonometric Survey of India shows that a Commission was appointed to report on its merits, and that as a result of the report all their parties will soon be equipped with it.

The Coast Survey is not the only government agency engaged in leveling. The Survey confines itself to running standard lines which it connects with mean sea-level, at various points along the coasts, the datum planes being derived from long series of tidal observations. The coöperation between various agencies of the government is shown by the fact that all the principal lines of level, those by the Geological Survey, by the Deep Waterways Commission, the Mississippi and Missouri River Commissions, and by the Lake Survey, are utilized by the Coast and Geodetic Survey in a general adjustment which will serve for all time as the basis of heights in this country. The value of this work will continue to increase from generation to generation. The elevations of the bench marks in the precise level net east of the Mississippi River will be held as published, while the next adjustment will fix the final elevations of the bench marks in the net of precise leveling to the westward of that river.

One phase of leveling, which is of scientific interest, was connecting the mean tide level at San Diego with mean tide level at Seattle, where a difference of over 3 feet was found. Had the levels been run along the sea-shore from San Diego to Seattle, no difference would have developed assuming the work to have been accurately done. But as the lines were run up to and over high plateaus in the interior, and down again, it was found that the orthometric correction had to be applied, and this brought the operations into perfect accord. That is, the apparent difference of level was due to the route followed. This results from the consideration that two water-level surfaces, one above the other, will not be parallel as one travels north or south. In running east and west it makes no difference, but in running north and south this becomes a measurable quantity.

Our Northern Boundaries.—The Superintendent of the Coast and Geodetic Survey is Commissioner for the demarcation of the Alaskan boundary, and for that portion of the northern boundary of the United States extending from the Pacific Ocean to the Bay of Fundy, with the exception of the boundary running through the Great Lakes. The beginning of the settlement of the boundary, through Passamaquoddy Bay, goes back to the Treaty of Peace of 1782; the settlement of disputed questions was again provided for, in the Treaty of Ghent, in 1814, but certain portions of the line were not settled until

with it irritating questions as to the precise location of the boundary line. For the settlement of these questions a joint treaty covering the boundary from end to end was exchanged and ratified, in 1906, although prior to that time an international commission had been at work in a less formal way in restoring old monuments and tracing the boundary where international questions had made it necessary. The triangulation has been extended from the Pacific Ocean to the summit of the Rocky Mountains, and this part of the line has been monumented with aluminum bronze monuments, as shown in Fig. 3.

To the east of the Rocky Mountains this same thing has been done, at the present time, to within 100 miles of the Lake of the Woods, and the whole boundary has been carefully mapped, for a short distance, on each side of the line. Progress has also been made in surveying the thickly wooded region extending from Lake Superior to the Lake of the Woods, and further to the east the monumenting and surveying is in progress along the northern boundary of Maine.

All this work is done by international coöperation, under two commissioners, one representing Great Britain and the other the United States.

Probably more has been said of the demarcation of the Alaskan boundary than of this northern boundary. The Alaskan boundary work has been going on simultaneously ever since the tribunal, in London, in 1903, settled the vexed question of the location of the southeastern boundary of Alaska. The greater portion of this line runs from mountain peak to mountain peak over inaccessible fields of snow and ice. Starting on the 141st meridian, a little to the west of Mount St. Elias, the line follows these Alpine summits to the head of Portland Canal, and down that canal to the vicinity of the historic parallel "Fifty-four, forty, or fight," and thence to the Pacific. Wherever it was possible to place monuments it was done, especially at all river crossings in the passes; all of the mountain peaks were trigonometrically located and the region was mapped phototopographically. From photographs taken at determined trigonometric points maps were made by geometric construction. It is hardly necessary to say that the reports of the surveyors, who conducted this difficult and hazardous enterprise, are full of thrilling adventure, but only two lives have so far been sacrificed. Many of the men had the unpleasant experience of dropping into glacial chasms, from which they were rescued, but the two men who lost their lives fell into an abyss and their bodies were never recovered. The field work

spans the boundary and the topographic mapping of a strip about two miles wide on each side of it. Aside from the immediate purpose of the delimitation, this work will serve as an admirable basis for co-

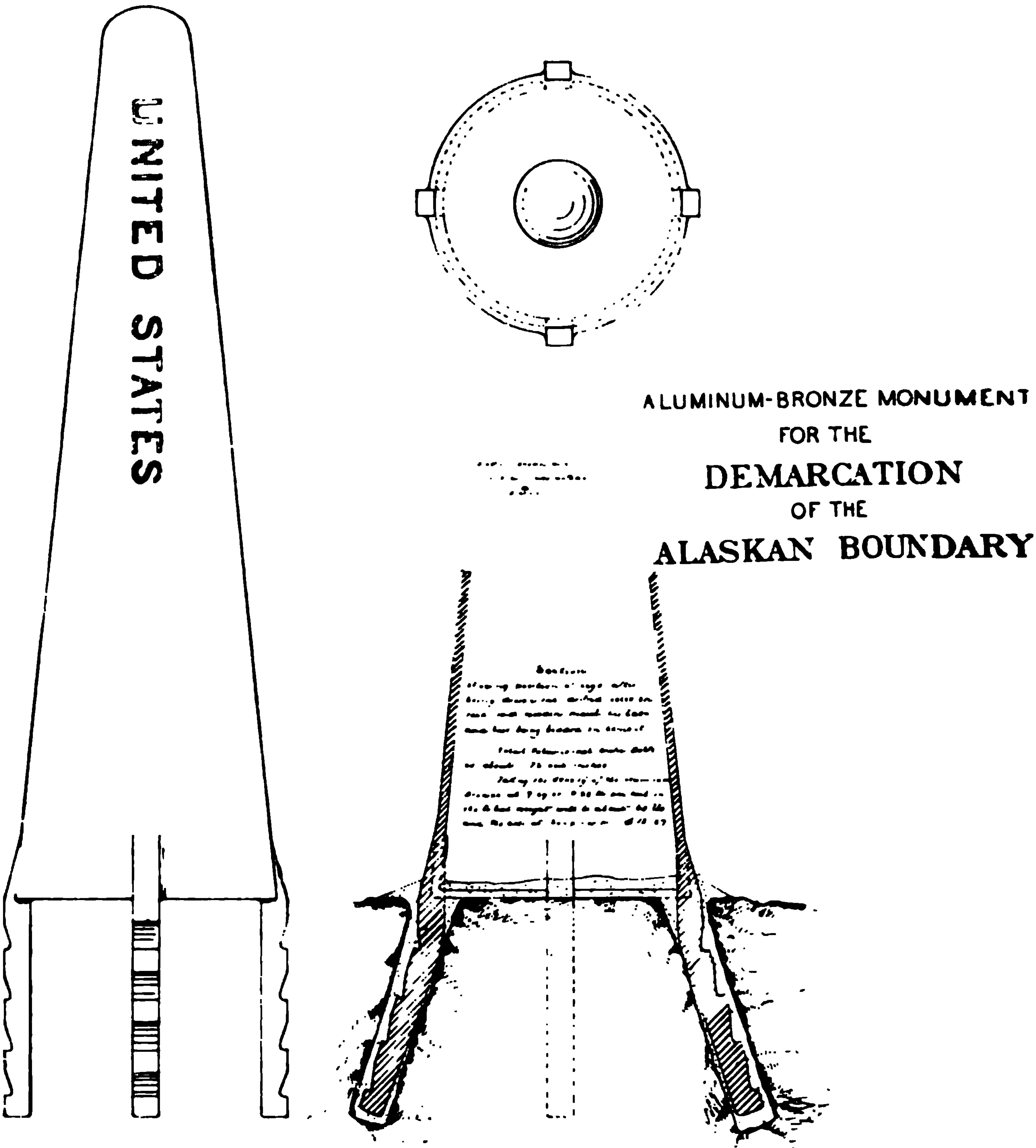

FIG. 9.

ordinating the land and economic surveys which will follow in another generation or two.

Fig. 5 shows the southern limit of the work which has been accomplished. It is only a provisional limit for it will be necessary to go about 90 miles farther south, through the mountainous ice field

are looking with great interest toward those who are trying to develop in governmental institutions the strong scientific features which will tend to make our American civilization stable.

Professor Tittmann has been giving a brief account of the vast enterprises over which he presides, and I think we should extend our sympathy, and at the same time our hearty congratulations to him and his co-workers for such high effort toward making the United States notable, not for its "spread-eagleism," but for its scientific enterprise.

E. L. INGRAM (member).—In 1891–95 I had the laying-out of about 500 miles of the boundary line between the United States and Mexico, from El Paso to the Pacific Ocean, and, although the country we passed through was bad enough, it was not as bad as the country we have seen on the screen to-night. From a technical point of view, I think the most interesting question with which we were concerned was, What is meant by a straight line on a spheroid? A straight line on a sphere is understood by surveyors to mean the arc of a great circle, but this definition is not applicable to a spheroid, which for practical purposes may be regarded as the shape of the earth. A line 500 miles long may vary in location as much as 10 feet at the center, according to the definition adopted for a straight line. The boundary which we were locating had two lines, one 260 miles long and one 150 miles long, which by treaty were required to be straight. I think we spent about three days in discussion and computation on this phase of the subject, and then found that as far as our lines were concerned the possible variation under any accepted definition of a straight line would be less than a single inch, which was much less than the probable errors of location.

There was one point brought out by Professors Tittmann and Doolittle, which is of considerable interest to geodesists, and that is the question of the variation of latitude. The reports that appear in the scientific journals from time to time are more or less indefinite and obscure. The general sense of these reports seems to be that the poles of the earth are not fixed, but perform what may be called a revolution around a mean point in an average period of about 425 days, with a radius varying from 0.16 seconds (16.3 feet) to 0.36 seconds (36.3 feet), the path of the moving poles being irregular and different on each successive revolution. The result of the constant shifting of the poles not only causes continual variation in the latitude of any given point, but all latitudes, longitudes, and azimuths become variable quantities, subject to an unceasing oscillation about their mean value. I would like to ask Professors Tittmann and Doolittle how far my statement of the case is correct, in the light of present knowledge, and what additional information may be available.

C. L. DOOLITTLE (visitor).—I was connected with the survey of the northern boundary, from the Lake of the Woods to the Rocky Mountains, from 1873 to 1874–75, when the work was done, and much of what Prof. Tittmann has been telling us is quite familiar to me as I have been over the ground myself. The work the Coast Survey is doing now is to restore the monuments of the boundary as we marked it.

I was much interested in the accuracy with which those monuments could be placed. In the determination of the parallel we made observations for latitude, which fixed a point on this parallel. We then ran the tangent, as we called it, to the next station, 20 miles or so distant. The offsets from the tangent

to the boundary adopted were the combination of the curvature of the parallel with the amount of station error, the latter due to local deviations of the plumb line. You never get a plumb line which will be an exact normal to the surface. There will always be a deviation; we never found a case where there was not considerable deviation. This question of variation of latitude, which Professor Tittmann has been talking about, and which I have been working on for the last twenty-five or thirty years, will give us a range from 50 to 60 feet, and on this account, if I determine the latitude today, and I determine it six or seven months from now with absolute precision, I would likely get a point of 40 or 50, or in extreme cases, 60 feet from the point I occupied before. Some one has said in regard to the 49th parallel that there is a strip of 50 or 60 feet wide that belongs alternately to one country and the other. In other words, the boundary varies 50 or 60 feet.

I think Professor Ingram's question can be readily answered, for I would say that we know very little about it. We know what is taking place, but as to the cause of it, and as for formulating a law for it, if we could predict what is going to happen ten years from now this might be possible, but we know very well we cannot. We thought some years ago that we were in line with the direct solution of this problem. The theory is very definite, and was worked out long ago by Prof. Euler, who established, theoretically, that there ought to be such a variation, and, assuming the earth to be a rigid body, he found a period of about 10 months; efforts were made for a long time to discover such a period or such a variation, but all of the attempts, as far as I know, were based on the supposition that the period was 10 months.

Well, different ones had more or less to do with it and I think I was a sort of pioneer in that direction myself. Instead of working at this theory I tried, by observation, to find out what was taking place. Professor Chandler, of Cambridge, who was more prominently connected with it in those days than anybody else, published with a good deal of confidence a conclusion that he had reached as a result of the analysis of many thousands of observations made at various places, that the variation had a period of about 14 months instead of 10 months, but that superimposed on that was another period of one year, and that the combination of the two produced the changes and irregularities that Professor Ingram referred to. This hypothesis can be made to fit the observations for a considerable period but it does not follow on to predict what is going to happen. You can take observations and fit such a curve to them but, if exterpolated a year or two ahead, it will not fit the observations at all. At present it is impossible to predict the position of the actual pole in regard to the mean pole. It appears to depend, to some extent at least, on meteorological causes, and if that really has much to do with it, it would be a proposition on the same order of difficulty as predicting the weather for long periods ahead. When we are able to solve this problem perhaps we may attack this latitude problem with some hope of success.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

REGULAR MEETING, October 18, 1911.—Present: President Hess, Vice-President Hutchinson, Directors Mebus, Swaab, Wood, Kerrick, Worley, Develin, Gilpin, Vogleson, Haldeman, the Secretary and the Treasurer.

It was ordered that a special memorial of our late President, James Christie, be reprinted from the Proceedings of the Club, and specially bound. The execution of this was left to the Committee on Publication.

The committee on the regulation of smoking in the meeting-room presented a progress report.

The Secretary presented a report of the financial condition of the Club, which showed a gain in operating expenses for the first nine months of the year of $828.79.

The matters of depreciation and insurance were discussed, and were referred to the Finance Committee, to report at the next meeting of the Board of Directors.

It was ordered that a Committee be appointed to prepare a method of procedure to be followed in regard to delinquent accounts.

It was moved and carried that the credit of all members of the Club be absolutely limited to $50.00, except that the room rent of permanent residents of the Club house be not included in this amount.

Mr. Worley presented correspondence received from Mr. Hering, making certain complaints in the management of the house.

It was moved and carried that the House Committee be informed that it was the sense of the meeting that monthly rates be charged for rooms when the occupancy exceeded a month.

Mr. C. A. Albrecht's resignation was accepted, as of July 1, 1911, provided his account prior to that time be settled in full.

The following resignations were also read and accepted: Walter C. Kennedy, John Reilly, Jr., John M. Weiss, and R. C. Williams, Jr.

It was ordered that a sum not exceeding $125.00 be appropriated to the Entertainment Committee to give a Club Smoker, on November 11, 1911.

It was ordered that the regular meetings of the Board in the future be held on the Thursday preceding the second meeting of the Club in each month.

REGULAR MEETING, November 16, 1911.—Present: President Hess, Vice-Presidents Plack and Hutchinson, Directors Swaab, Wood, Worley, Cooke, Develin, Gilpin, Vogleson, Haldeman, the Secretary and the Treasurer.

The Secretary presented a statement of the financial condition of the Club, which showed a gain in operating expenses for the first ten months of the year of $655.90.

The matter of delinquent accounts was discussed at some length.

Mr. F. H. Stier was added to the Committee on Delinquent Accounts, making

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, September 16, 1911.—The meeting was called to order by President Hess, at 8.30 p. m., with 62 members and visitors in attendance. The minutes of the Regular Meeting, of June 3rd, were approved as printed in abstract.

The Committee on Nominations, viz., Wm. Easby, Jr., chairman; H. H. Quimby, J. C. Wagner, W. B. Riegner, Herbert Rice, H. E. Ehlers and Wm. C. Kerr, proposed by the Board of Directors, at the meeting of the Club on June 3rd, was approved.

A Memorial of the late James Christie, prepared by Dr. Henry Leffmann and Mr. John C. Trautwine, Jr., was presented by Dr. Leffmann.

It was announced that at the Regular Meeting of the Board of Directors, held September 5th, Mr. Henry Hess had been elected President of the Club, Mr. Edward S. Hutchinson elected as first Vice-President, and Mr. B. A. Haldeman member of the Board, all these elections for terms to expire February, 1912.

Dr. David S. Flynn, Sanitary Expert of the Catskill Aqueduct Commission, presented the paper of the evening, entitled, "The Sanitary Supervision of the Catskill Aqueduct," which was discussed by Messrs. E. S. Hutchinson, H. C. Berry, Henry Leffmann, Robert Schmitz, S. M. Swaab, and others.

Upon motion of Dr. Leffmann, a vote of thanks was extended to Dr. Flynn.

Business Meeting, October 7, 1911.—The meeting was called to order by President Hess, at 8.30 p. m., with 92 members and visitors in attendance. The minutes of the Business Meeting, of September 16th, were approved as printed in abstract.

Following a report of the Tellers, the President declared the following elected to membership in the Club: Associate, Charles Wilke, Junior, William L. Brown and Walter S. Crowell.

Mr. C. J. Ramsburg presented the paper of the evening, entitled, "Gas Production with Special Reference to the Manufacture and Distribution of Illuminating Gas in Cities," which was discussed by Messrs. H. H. Quimby, Robert Schmitz, W. P. Dallett, Carl Hering, Henry Leffmann, John C. Trautwine, Jr., Harrison Souder, and others.

Upon motion of Mr. E. M. Evans, a vote of thanks was extended to Mr. Ramsburg.

Regular Meeting, October 21, 1911.—The meeting was called to order by Vice-President Hutchinson, at 8.25 p. m., with 189 members and visitors in attendance. The minutes of the Business Meeting, of October 7th, were approved as printed in abstract.

Mr. John W. Ledoux presented the paper of the evening, entitled, "The Failure of the Austin Dam," which was discussed by Messrs. Edwin F. Smith,

Carl P. Birkinbine, John C. Trautwine, Jr., J. E. Gibson, George S. Webster, Manton E. Hibbs, and others.

Following the discussion, it was moved and carried that a committee of the meeting be appointed by the Chair to consider the discussion relating to the subject of Governmental Control of the Construction of Dams in Pennsylvania, and to report at the next business meeting of the Club. The Chair then appointed the following Committee: Edwin F. Smith, Chairman; John C. Trautwine, Jr., John W. Ledoux.

BUSINESS MEETING, November 4, 1911.—The meeting was called to order by President Hess, at 8.30 P. M., with 102 members and visitors in attendance. The minutes of the Regular Meeting, of October 21st, were approved as printed in abstract. The Committee on Governmental Control of the Construction of Dams in Pennsylvania presented a progress report, and stated that it would probably present its final report at the next meeting of the Club. Mr. John Birkinbine spoke briefly on this subject.

Prof. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, presented the paper of the evening, entitled, "The Present Activities and Progress of the Coast and Geodetic Survey," which was discussed by Mr. E. M. Nichols, Prof. Doolittle, Prof. Snyder, Mr. John C. Trautwine, Jr., Prof. Ingram, and others.

It was moved by Mr. Trautwine and carried that, in thanking Prof. Tittmann for his interesting paper, a message of appreciation and congratulation be given to him and his associates for the advances made in the work of the survey.

BUSINESS MEETING, November 18, 1911.—The meeting was called to order by President Hess, at 8.30 P. M., with 72 members and visitors in attendance. The minutes of the Business Meeting, of November 4th, were approved as printed in abstract.

The Committee on Governmental Control of the Construction of Dams in Pennsylvania presented both a majority and a minority report. Following a brief discussion, it was ordered that both the discussion and the action upon these reports be laid over to a special meeting of the Club, to be held on Saturday, December 9th.

The Committee on Nominations presented the following nominations for officers of the Club for the year 1912: President, Henry Hess; Vice-President, Charles F. Mebus; Secretary, W. P. Taylor; Treasurer, F. H. Stier; Directors, H. C. Berry, B. A. Haldeman, S. M. Swaab, D. R. Yarnall.

Mr. J. C. Meem presented the paper of the evening, entitled, "The Theory of Earth Pressure," which was discussed by Mr. H. H. Quimby, Dr. H. M. Chance, and others.

Upon motion of Dr. Chance, a vote of thanks was extended to Mr. Meem.

BUSINESS MEETING, December 2, 1911.—The meeting was called to order by President Hess, at 8.30 P. M., with 64 members and visitors in attendance. The minutes of the Business Meeting, of November 18th, were approved as printed in abstract.

Following a report of the Tellers, the President declared the following elected

to membership: Active, John B. Dilworth, John J. Gartland, Jr.; Associate, Jared S. Kenyon; Junior, Ernest Hagenlocher.

Mr. Arthur P. Davis, Chief Engineer of the U. S. Reclamation Service, presented the paper of the evening, entitled, "Reclamation Engineering in Russian Turkestan," which was followed by a short discussion by Messrs. W. C. Furber, E. M. Nichols, and others.

Upon motion of Mr. Nichols, a vote of thanks was extended to Mr. Davis.

SPECIAL MEETING, December 9, 1911.—The meeting was called to order by Vice-President Plack, at 8.30 P. M., with 48 members and visitors in attendance. The majority and minority reports of the Committee on Governmental Control of the Construction of Dams in Pennsylvania were brought up for consideration, and, following a discussion in which the following took part—Edwin F. Smith, J. C. Trautwine, Jr., J. W. Ledoux, J. C. Parker, John Birkinbine, Henry Leffmann, J. E. Gibson, Manton E. Hibbs, G. S. Cheyney, H. H. Quimby, J. W. Hunter, and others—the following resolution was adopted:

WHEREAS, the failure of the Bayliss Pulp and Paper Company's Dam on Freeman's Creek, above Austin, Pa., on September 30, 1911, calls attention to the importance of insuring the safety of such structures where failure is a serious menace to human life. Therefore, be it

Resolved, that such structures should be entrusted only to engineers of ability and experience, who should have constant supervision of every phase of the construction; and, be it further

Resolved, that the Governor of the State is, therefore, requested to call together a special Commission of competent engineers, aided by legal talent, to frame comprehensive regulations providing for the creation of a State Department of Public Works, to be composed of bureaus so constituted that their combined jurisdictions should cover not only the construction of dams but all other engineering contingencies likely to arise in the near future.

It was further ordered that a copy of this resolution be sent to the Governor of Pennsylvania.

BUSINESS MEETING, December 16, 1911.—The meeting was called to order by President Hess, at 8.30 P. M., with 76 members and visitors in attendance. The minutes of the Business Meeting, of December 2nd, were approved as printed in abstract.

Mr. Robert Schmitz presented the following resolution for discussion at the next meeting of the Club: "That the other engineering societies and clubs in this State be asked to consider resolutions on the governmental control of engineering structures, and, if possible, that their coöperation be obtained in securing legislation in this matter."

Prof. Gardner S. Williams presented the paper of the evening, entitled, "The Water Power Plant of the City of Sturgis, Michigan," which was discussed by Messrs. J. C. Trautwine, Jr., H. M. Chance, J. E. Gibson, Robert Schmitz, and others.

On motion of Mr. Webb, a vote of thanks was extended to Prof. Williams for his interesting paper.

same name. To the engineer, energy is a physically measurable quantity, best known to us as mechanical work. As chemistry teaches that coal, graphite, and carbon all represent the same substance, carbon, insofar as each of these may be changed into the other, so does physics teach that mechanical work may be changed into heat, light, electricity, chemical effects, etc. As impossible as it is to increase or decrease a given quantity of carbon by the most complicated transformations, so impossible is it to increase or decrease a given amount of work by the most intricate transformations. For both there rules the law of conservation. That which we can neither create nor destroy we call a substance; thus the chemical elements have the character of substances, as have also work and its transformation products. These latter are given the common term "energy," while the science of the laws governing the manifold transformation of energy is "energetics."

Prefacing that this is all well known, Ostwald answers the question for the reason of this repetition by the statement that these laws not only regulate, but even make possible, our very existence. Life is based on a continual change of energy in our body; with the instant of interruption of this change death ensues. But not only individual life, but all social life also, is directly dominated by the laws of energy. That a speaker may appear before you is due to the energy of some means of conveyance; that you hear a speaker is due to the energy conveyed from his vocal cords to you in sound-waves; that you understand a speaker is based on the energy of your own mental activity. That is why we must, first of all, be practicers of energetics, long before we may choose any other view of the world *why nothing may happen without the participation of energy in various forms!*

While the fact of energy is an every-day one, with the term not nearly so well known, the condition is exactly reversed as to culture. The word is generally familiar, but an agreement between any two or three educated people as to a definition will be hard to secure. There are many definitions of this term which it would seem impossible to give a common denominator. But the usefulness of energetics will show itself in its ability to embrace all of the many sides of the cultural problem. All life, individual as well as social, utilizes those forms of energy that it comes into contact with for its own purposes by suitably transforming them. The result of this transformation may be great or little, as compared with the energy expended,

tiveness of this method is clear from the fact that one one-hundredth part of slit width in one color makes a perceptible change. It is thus possible for a dealer in Philadelphia to tell his dyer in Paris that he wants a certain silk dyed to 50 red, 30 blue, 81 green, and,

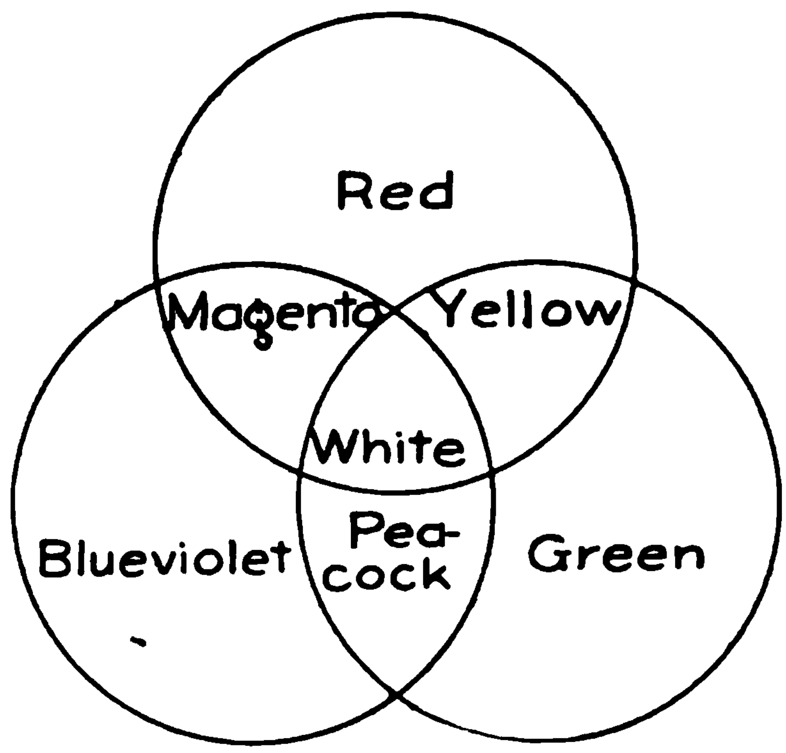

FIG. 4.—Primary Color Mixtures.

if both have an Ives colorimeter, to get an absolute match with greater certainty than by any exchange of samples and the usual reliance on the eye.

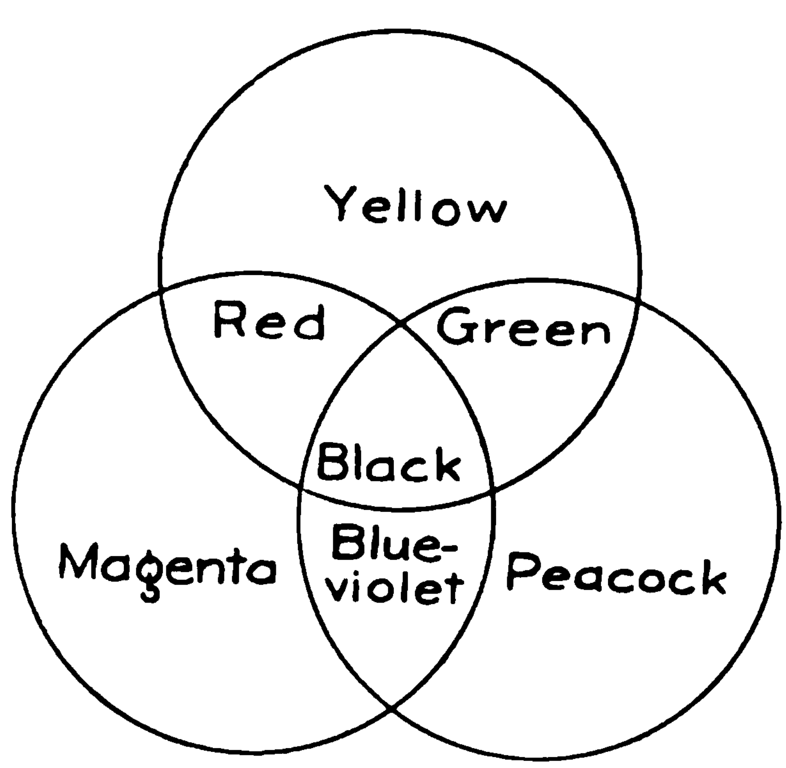

FIG. 5.—Secondary Color Mixtures.

The principle of color mixture is shown by Figs. 4 and 5, in which on one side three circular discs of red, blue violet, and green overlap partly; the center, where all three lap, is white; the lapping colors,

termed secondaries, are yellow, peacock, and magenta; the other side shows a similar arrangement, but the discs are the secondaries; the superposition of all three at the center gives complete black, theoretically; practically, an approach that will satisfy the eye. The colors on the screen are not exact, owing to the admixture of yellow light emanating from the arc light operating the lantern. The lapping of any two of the secondary color discs of Fig. 5 gives back as a combination result the original primaries, red, green, and blue violet.

It is my privilege to have induced Mr. Ives to construct a colorimeter for use with the projection lantern, capable of showing on the screen the combination and matching of colors, as well as the resolution of any combination color into its primaries, not only quantitatively, but also qualitatively; this is the first time that this has been accomplished, and I am particularly pleased that, in connection with my introductory address as your President, Mr. Ives allows me to present this to the scientific world through this Club.

Of the two white fields side by side on the screen, one is due to the arc-light directly, and the other due to light from the same arc passed through transparencies of the three primary colors; the width of the color slits has been regulated so that the proper quantity of each color passes to combine into and match the direct white. Placing now various simple and complex colors in place of the direct white field, you will note that, by suitably varying the width of the three primary color slits, the two fields are made to match. Please note also the very noticeable change in tint that results from a variation of only 1 per cent. of the width of one of the slits. With a very little practice a user of this apparatus soon learns which of his three primaries he must add or subtract to match the color under examination.

While the three primary color theory is most generally accepted, there are those that assert that four primaries should be used as a basis for color analysis. So far as the colorimeter is concerned, it can deal with any number of primaries, as it is only necessary to provide as many mixing slits as there are primaries—two, three, four, or any desired number.*

It was stated that this colorimeter was devised by Mr. Ives in

* Various colors were thrown on the screen, analyzed, and matched. There were also shown, by means of this projection apparatus, the varying tints of different lights as compared with daylight, and the admixtures of colors producing these variations.

connection with his work in three-color photography. Mr. Ives was the first really successful pioneer in three-color photography, though some preliminary work has been done by Ducos Du Hauron, of France, and others. To date, the greatest advance toward really satisfactory reduction to broad practicability is again due to our distinguished fellow-townsman.

No doubt a brief recital and a few examples of the various methods now in use will interest you. The screen shows you a series of parallel lines of red, blue, and green. In the original slide these are very narrow—too narrow, in fact, to be distinguishable by any but the very sharpest of eyes. This next slide shows these lines still more plainly by microscopic projection. When a series of such lines are viewed at a sufficient distance, or the lines are of such small width as to be individually indistinguishable, they will combine to give the effect of white, provided, of course, that proper primary tints of sufficient purity and quantitatively correct have been chosen. If, in any way, say the blue-violet lines are suppressed or obscured, then the remaining red and green will combine to yellow. If such a screen be ruled on a glass plate and covered with a sensitive photographic emulsion and that exposed to the light from a colored object falling through the screen, then the local darkening on development will prevent transmitted light from reaching the eye, and so cut out more or less of the primary color lines, giving the effect of a transparency in natural colors. This method is due to a number of workers, as Du Hauron, Joly, Mc Donough, and others. Later workers along this line have replaced the ruled lines with stipples or dots of primary colors. Such a screen, due to Lumière, consists of more or less irregular agglomerations of red, blue, and green dots. Each dot is a dyed starch-grain particle, potato starch having been selected because of the minuteness of the grains. A much more regular arrangement, though of much larger dots, is the "Thames" screen. Still another, made up of alternating green and blue lines, crossed at an angle of about 30 degrees by red lines, is the German "Krayn" screen, made by pasting alternate blue and green thin celluloid sheets together, and cutting a veneer from the edge of the resulting block. The red lines are later printed on the veneer.

By comparing the light falling through these various screens with the light falling through three thicknesses of clear celluloid it is apparent that the various screens all absorb relatively large amounts of light—some more than others. As the light reflected from an

object to be photographed must pass the screen before it reaches the sensitive film, it is clear why color photography is relatively slow; it requires exposure about twenty times as long as direct monochrome work with the same films.*

This general method of color photography by line and stipple is capable of very good results in the hands of those highly skilled. But the plates are expensive and delicate, and the many manipulations are wearisome and difficult to carry out. Then they give only a single original, which cannot be satisfactorily manifolded. Moreover, that original is a transparency. Furthermore, if the light falling through it is necessarily different from that by which it was taken, the color effects are falsified. These transparencies should always be viewed by diffused daylight, or by light reflected from a white background. Used in the lantern, the magnification shows up the disturbing line or stipple screen. Owing to their relative density, much more powerful lanterns are necessary for line or stipple color slides than for ordinary lantern slides.

Mr. Ives approached the subject from another angle. He boldly decided on superposing three transparencies, one representing all the various gradations of red of the object, another of the green, and the third of the blue violet. Superposed in register, it is clear that these must give a correct color composite of the object. The difficulties were many and multifarious. The colorimeter had to be devised to test out and select from the many possible dyes those giving the nearest effects to truth; then these had to be sifted further for permanency; then the varying shrinkage of the films, destroying correct registry, had to be overcome, etc. Finally, the camera itself and the plates had to be drawn into the work of improvement. In a general sense any camera would answer, particularly when stationary objects are to be photographed. There would first be made an exposure for the reds, then a second one on a second plate for the greens, and then a third on a third plate for the blue violets. But as that required three successive exposures, and since registry of the three plates would manifestly be impossible if the object moved between exposures, this method was restricted to stationary objects. Nor could three simultaneous exposures be made with three separate or combined cameras, as each necessarily viewed the

* A number of natural color transparencies by these various line and stipple screen methods were projected on to the screen.

object from a slightly different angle. Mr. Ives devised a beautiful solution of that elegant simplicity characteristic of his work in general.

In Fig. 6 the camera body A is of the box type, with the usual lens system B. The plate-holder is carried at the back in the usual way, but carries two plates, C and D, the rear one having its film side nearest the lens, and the one in front of this having its film face to face with the rear one. A third plate, E, lies in the bottom of the camera. Light from the object passes through the lens system, and a compensating color screen, F, immediately behind the lens system. The light next strikes a clear glass, G, that is placed at an angle of forty-five degrees. The front face of this glass acts as a mirror to deflect

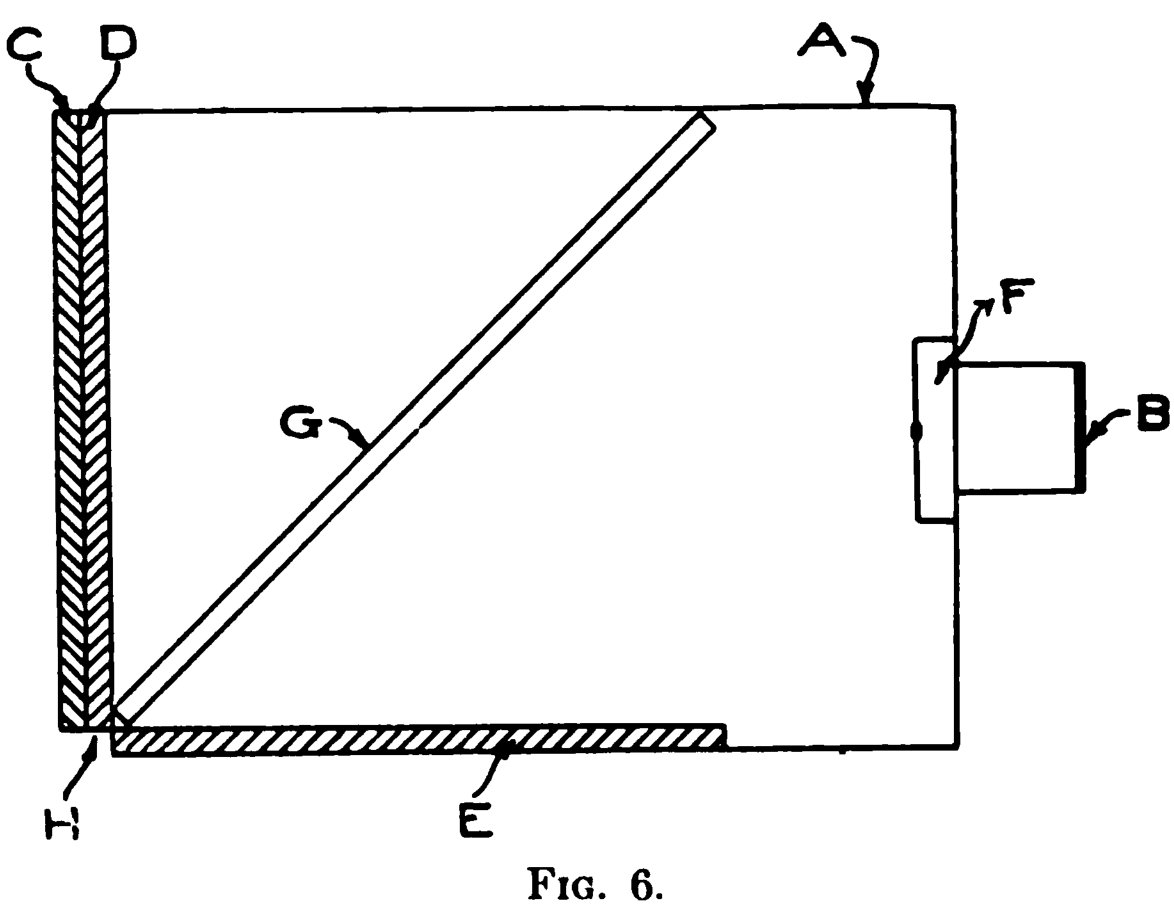

FIG. 6.

part of the light to the bottom plate, E. The remaining light passes through the glass G, through plate D, to act on the sensitive rear face of D and on the sensitive front face of plate C. It is clear that a single exposure suffices for making the three plates, C, D, and E. Each of these plates must, of course, select its particular primary color. The principle under which they do this is old, consisting of the filtering out by suitable interposed color filters. These color filters are located as follows: The compensating screen F acts also as a color filter; a second one is supplied by a varnish on the back of the inclined transparent mirror, G, and, finally, the sensitive film of D is suitably dyed to filter for plate C. Much work and patient

investigation and experimenting were necessary to secure the proper relationship of the sensitive plate emulsions, different for each of the three plates and of the color filters. Some of the difficulties may be imagined when it is realized that, even though all the light filters were of proper color and purposely balanced as to intensity of color, an emulsion slightly too fast or too slow on one plate would result in that plate being too dense or too thin, and so give not enough or too much of its color in the final result.

The arrangement of the three plates for convenient handling is also worthy of note. All three plates are attached at their lower edges, H, to a strip of gummed paper, on which they hinge like the leaves of a book. They are inserted as a unit into the plate-holder, which is slid into the camera back in the usual way. At this time the mirror, G, is held up out of the way at the top of the camera by a simple catch. When the plate-holder slide is withdrawn, that allows the first plate, E, to fall downward to its position, as shown in Fig. 6. Plates C and D cannot fall, being slightly larger than the front opening of the holder. The mirror, G, is then dropped to place, and the exposure made precisely as with any ordinary camera. This camera can, in fact, be used for ordinary work by simply leaving the mirror, G, at the top, and using ordinary single plates, roll films, or film packs. Ordinary cameras of the box type may also be readily converted for color work by adding the mirror G and slightly adapting the plate-holder slide.

The plates are developed in the usual way; the best method is by fixed time development in a standard solution, glycin preferred. A convenient arrangement is also due to Mr. Ives, consisting of a simple tank adapted to take the triple plate pack ("tripak"), with the three plates spread apart like the leaves of a book, for convenient access by the developer. Only a single developer is required, acting five to eight minutes, and the ordinary fixing in hypo and water washing. To print out, all three plates are placed side by side in a long printing-frame and the film exposed. The film is gelatin bromid, carried on a very thin celluloid backing. When the proper exposure has been made, by the aid of a very simple tint exposure meter, the film is washed out in hot water until it is clear, and then passed through a hypo. The film is now cut apart, and the three films laid each into its dye-bath of peacock-blue, magenta, and yellow respectively. In about five minutes each will have absorbed the proper amount of dye. As the absorption

power of the film and the dye-baths are all standardized for proper relationship, a more prolonged dyeing has no appreciable effect, and neither skill nor judgment as to proper dye density is needed. The dyed prints are dried in the usual way, placed in register over one another, and bound securely at the edges by passe-partout paper. For lantern slides they are also bound between clear glass plates. Obviously, any number of transparencies may be made from one set of plates. The entire process is exceedingly simple, and, owing to the thorough standardization of all the elements for themselves and in their interrelation, the results are uniform and independent of special manipulative skill or judgment.

This whole chapter of progress on the production of correct color transparencies in any quantity from a single exposure may now be said to be beyond the realm of the laboratory, and to have definitely arrived at that stage of perfection required for broad general public use. With it Mr. Ives has added to his achievements as the originator and perfector of the half-tone printing process and of the three-color printing process the further one of direct practical three-color transparency photography.

With the characteristic energy of the truly scientific inventor, Mr. Ives is already hard at work on the conquest of new worlds, and I have been privileged to see very nearly perfected color photographic prints for direct vision. I trust that it may be my privilege to have the final result brought before the world for the first time through this Club.*

* A number of slides were shown illustrating various color phenomena, as color fringes, interferences, bands, etc.

PAPER NO. 1107.

PROPULSIVE MACHINERY AND OIL FUEL IN THE UNITED STATES NAVAL SERVICE.

CAPTAIN C. W. DYSON, U.S.N.
(Visitor.)

Read January 6, 1912.

UNTIL within the last few years the improvements in propelling machinery for naval vessels, and for marine purposes in general, were few, the designers apparently considering that the reciprocating engines which they were then using were good enough, and that any further improvements in them could be made only at an undesirable increase in weight, in cost, and in complication.

This apparent view extended not only to the main propelling machinery, but also to the auxiliary machinery, with the result that each new ship was practically a copy of those that preceded it, only such modifications being made as the necessities of the particular case dictated.

With the advent of the turbine it became necessary, in case the reciprocating engine was to hold its own, to take advantage of every possible opening for improvement. Such improvements as appeared possible at the time of laying down the designs were made, and that they were desirable has been amply shown by the results on trial and in service obtained by the U.S.S. South Carolina, Michigan, and Delaware.

In the adoption of turbine machinery the Navy Department proceeded with characteristic caution, and no designs of this type of machinery were laid down until results obtained abroad were of such nature as practically to insure success.

In the fall of 1904 it was determined to lay down three scout cruisers, Birmingham, Salem, and Chester, and in order to obtain data for use in future designs it was decided to fit the Birmingham with reciprocating engines, the Salem with Curtis turbines, and the Chester with Parsons turbines.

Before these vessels were completed, in June, 1907, the Fore River Shipbuilding Company completed and tried out the Southern

Improvements in Reciprocating Engines.

For battleship work, in order to meet the turbines on more even ground, the principal changes made in the design of reciprocating engines are as follows:

1. Increase in ratio of L.P. to H.P. cylinder volumes from about 7 to 1 to about 10 to 1.
2. Lengthening the main steam valves in order to give short and straight steam and exhaust ports, with consequent reduction in clearances and in steam frictional losses.
3. Increase in vacuum carried in main cóndensers.
4. Use of superheated steam.
5. Slight decrease in bearing pressures of crank-pins and cross-heads.
6. The fitting of forced lubrication to crank-shaft, crank-pin, and cross-head journals and to eccentrics and to cross-head slides.

All these changes have not as yet been made, but 1, 2, and 4 were utilized in the engines of the South Carolina and Michigan, 1, 2, 4, 5, and 6 in the engines of the Delaware, and 1, 2, 3, 5, and 6 in the engines of battleships Nos. 36 and 37, the designs of which have just been completed by the Navy Department.

Results Obtained by the Above Changes.

Unfortunately, in the cases of the South Carolina and Michigan, no measurements of actual water consumptions of the machinery were made on the trials of these vessels. An idea of the economy realized can be obtained, however, by comparing them with their sister ships of the Connecticut class, the Delaware also being included in the tabulation:

	Minnesota.	Michigan.	Delaware.
Heating surface of boilers, sq. ft.	52,752	42,500	55,749
Superheating surface of boilers, sq. ft.	..	4,720	6,149
Total grate surface per sq. ft...	1,100	886 eq. 1,148.25 act.	1106 eq. 1439 act.
I.H.P. all machinery	20,783	19,680.6	29,529
Sq. ft. of H.S. per I.H.P.	2.538	2.159	1.888
Sq. ft. of H.S. per I.H.P. (total)	..	2.4	2.096 eq.
I.H.P. per sq. ft. grate surface.	18.894	22.21 eq.	26.7 eq.
Air-pressure in inches of water.	0.92	0.85 act. 1.00 eq.	2.43 1.86 act.

Let us compare the above results still further, using a series of vessels having the same type boilers as the above vessels, but all being without superheat and having the old type of naval engines.

In the above table and in the following one the boilers are all reduced to a standard ratio of generating heating surface to grate surface of 48.1, and the air-pressures calculated as varying inversely as the ratio of the equivalent grates to the actual ones.

VESSELS WITH OLD-TYPE ENGINES AND NO SUPERHEAT.

	Minnesota.	Montana.	Mississippi.	Charleston.
Heating surface	52,752	68,000	32,648	64,000
Total grate surface	1,100	1,590 act. 1,418 eq.	768 act. 681 eq.	1,400 act. 1,343 eq.
I.H.P. all machinery	20,783	28,280	13,906	27,507
Sq. ft. of H.S. per I.H.P.	2.538	2.404	2.347	2.323
I.H.P. per sq. ft. G.S.	18,894	20.0 eq.	20.405 eq.	20.62 eq.
Air-pressure in inches of water	0.92	1.19 act. 1.33 eq.	1.3 act. 1.47 eq.	2.48 act. 2.6 eq.

Plotting the results obtained from the above tables on Plate I, we see that for an air-pressure of 2 inches of water, which is the naval limiting pressure for coal-burning Babcock and Wilcox boilers, which are fitted in all the above vessels, the use of superheat and the improved engines gives 25.6 I.H.P. per sq. ft. of grate against 20.6 I.H.P. per sq. ft. of grate with the old equipment. This is a total increase in economy of 24.3 per cent. The commonly accepted saving due to superheat is estimated at 1 per cent. for every ten degrees, which, as the average superheat used in the above vessels at full power amounted to about 60 degrees, gives a total saving due to superheat only of 6 per cent., leaving a balance of 18.3 per cent. due to the improvements in the engines themselves.

Comparison of Water Rates of Old and New Types.

The only vessels having reciprocating engines for which accurate engine water consumption measurements have been taken, up to the present date, are the scout Birmingham and the battleship Delaware. The necessary engine data for comparison are as follows:

		Birmingham.	Delaware.
Diameters	H.P. cylinder	28¼″	38½″
	I.P. cylinder	45″	57″
	2 L.P. cylinders	62″	76″
Piston-rod diameters		6″	8″
Stroke of piston		36″	48″
Revolutions at full power		191.5	128.39
Piston speed at full power		1149′ per min.	1027′.12
H.P. mean		26.4	16.17
Per cent. clearances	I.P. mean	21.34	13.57
	L.P.	21.245	12.49
Steam pressure per gage in H. P. valve chest		229.4	253

The Birmingham engine, of course, is handicapped at the start by its smaller size, higher piston speed, and lower steam pressure, but these handicaps cannot possibly explain away the great differences existing between the steam consumptions per I.H.P. of the two types of engines at equal fractions of power. These consumptions are as follows:

	FULL POWER.	⅝ POWER.	⅛ POWER.
Delaware	13.38 lbs.	12.7 lbs.	15.12 lbs.
Birmingham	17.30 "	15.5 "	19.00 "
Per cent. decrease for Delaware	22.66 "	18.7 "	20.40 "

The above amounts include drainage from the jackets. All leakage from stuffing boxes is unaccounted for, but if this were taken into account, the difference would be still more favorable to the Delaware, as not the slightest evidence of leakage through her valve stem or piston-rod stuffing boxes existed during the trials.

The collier Cyclops has engines built along the same lines as the modern naval reciprocating engines, and the results obtained by her bear out fully the results obtained by the Delaware. Although no superheat exists in the case of the Cyclops, the water per I.H.P., measured from her indicator cards, shows at full power less than 12 pounds, neglecting leakage and cylinder condensation.

To show the effect of the short, straight steam ports on exhaust pressures, Plate 2, showing the amount of back pressure exerted per square inch of L.P. piston area for several engines of the old type and of the Delaware, is herewith submitted.

The very low pressure shown by the Delaware is not entirely due to the ports alone, but is partially accounted for by the fact that with the Delaware's engines no live steam was admitted to the I.P. and L.P. receivers during trials, full benefit being taken of the expansion of the steam from cut-off in the H.P. cylinder to the exhaust in the L.P. cylinder.

The Delaware's engines were still further aided in the search for economy by the forced lubrication system, which, by insuring that all bearings were oil borne, quite materially decreased the friction of the load, and thus allowed the engines to turn up more rapidly than would have been the case if this system had not been installed.

The following table, giving steam and exhaust velocities, will be of interest as showing the benefit of the straight ports in reducing resistance to the flow of the steam, and thus increasing the efficiency of the engines:

TABLE OF STEAM AND EXHAUST VELOCITIES.

Ship.	Revs. per Min.	Type of Port.	H.P. Steam Veloc. Ft. per Minute (Mean).	H.P. Exh. Ft. per Minute (Mean).	I.P. Steam Ft. per Minute (Mean).	I.P. Exh. Ft. per Minute (Mean).	L.P. Steam Ft. per Minute (Mean).	L.P. Exh. per Minute (Mean).
Delaware	130	straight	6,565	5,340	6,678	6,180	10,446	7,514
Michigan	125	"	6,723	5,289	7,883	5,909	9,947	7,199
Louisiana	120	crooked	5,670	5,480	8,262	6,670	10,833	7,450
Birmingham..	200	"	6,518	5,251	8,385	6,804	11,591	8,347

	Delaware.	Michigan.	Louisiana.	Birmingham.
Velocity through exhaust pipe to condenser	6,637	6,612	7,390	7,061
Velocity through main steam-pipe	8,275	8,463	8,380	7,078

All the above velocities are based on relative areas of ports and pistons and volumetric displacements per minute of the pistons. It should be further stated that the Birmingham never made 200 revolutions, but reached about 190 on trial.

Turbine Machinery for Battleships.

In the choice of type of turbine machinery for battleship propulsion the Navy Department has, up to the present time, placed turbines of the Parsons type and of the Curtis type upon an equal footing where weights and space allowed for the installation would accommodate either. In some cases the engine-room space may be very much restricted; when this is the condition, turbines of the Curtis type have a decided advantage over the Parsons, as the former type, with either one or two units per shaft, the total power being divided between two shafts, can be installed in much smaller floor area than the Parsons type, with its cruising turbines and high-pressure backing turbines, in addition to the main turbines, with the power distributed among four shafts.

An instance of this occurred in the case of the North Dakota. In this vessel the engine-rooms are only 44 feet in length. This length accommodated reciprocating engines, as in the Delaware, or a nine-stage single-unit Curtis turbine, although this resulted in a very crowded arrangement, but made the installation of Parsons turbines an impossibility if the cruising turbines were to be retained.

The Florida and Utah are both equipped with Parsons turbines

of a designed shaft horsepower of 28,000, divided among four shafts. The engine-room space required to accommodate this amount of power, together with the necessary cruising and backing turbines, is 51 feet wide by 60 feet long, while on the Wyoming and the Arkansas, with the same designed shaft horsepower as the Utah, the space has been reduced slightly to 48 feet 6 inches wide by 60 feet. In all four of these vessels the engine-rooms are much crowded, large as they are. When they are compared with the engine-room space of the reciprocating engine ship Delaware, which is 50 feet 6 inches wide by 44 feet long, we see that, with about the same width of engine-room, the reciprocating engine ship, in order to develop the same I.H.P. as shaft horsepower of the turbine vessels, requires 16 feet less in length. The importance of this saving in length is easily seen when we consider the additional displacement and armor, with consequent large increase in cost of hull, entailed when the vessel is designed for turbine propulsion.

Comparison of Engine-room Weights of Turbine and Reciprocating Engines.

At the time of writing this article the Bureau of Steam Engineering has available the completed weight sheets of only two comparable vessels, namely, the Delaware and the North Dakota.

The engine-room weights of the former vessel are 773 tons, while those of the latter amount to 783 tons. Practically no saving in engine-room weights can be looked for if turbine machinery is adopted in place of reciprocating engines for battleship propulsion.

Comparison of Efficiencies of Propulsion and Resultant Comparative Boiler Installations Required with the Two Types of Machinery.

In comparing efficiencies of propulsion the first point to be taken into consideration is the relative propeller propulsive coefficients which can be obtained with the different types of machinery used. As all three of the Dreadnaught battleships which have been tried, the Delaware, North Dakota, and Utah, had excellent to very good propellers, for the utilization of the high power, we will compare their individual propulsive coefficients with each other, taking their performances at 21 knots as a basis.

As all engineers understand, the term "propulsive coefficient" as usually applied means the ratio between the tow-rope horsepower

(E.H.P.) of the ship when fitted with all appendages and the I.H.P. in the case of reciprocating engines, or S.H.P. in the case of turbines. The Bureau of Steam Engineering assumes a mechanical efficiency of 92 per cent. for its large reciprocating engines, so that the true comparison of propulsive coefficient would be represented by the following formulas:

$$\text{Reciprocating propulsive coefficient} = \frac{\text{E. H. P.}}{\text{I. H. P.}}$$

$$\text{Turbine propulsive coefficient} = \frac{\text{E. H. P.} \times .92}{\text{S. H. P.}}$$

Using these two formulas, the propulsive coefficients of the three vessels at 21 knots were—

Delaware	122½ revolutions,	65 per cent. prop. coef.
North Dakota	265 "	53.82 per cent. prop. coef.
Utah	313 "	56.12 " " "

While the powers required for this speed were—

Delaware	23,400 I.H.P.	
North Dakota	26,500 S.H.P.	= 28,800 I.H.P.
Utah	26,400 S.H.P.	= 28,700 I.H.P.

For boiler comparisons, it is considered preferable to reduce conditions to one common condition of feed temperature and boiler pressure, and to compare the heat units absorbed by the boilers of each vessel in overcoming equal resistances of hulls. By doing this we find that at 12 knots' speed the Delaware'sboilers absorbed 119,500 B.T.U.'s against 142,700 B.T.U.'s for the Utah, or that it costs approximately 19.4 per cent. more to cruise at 12 knots with the turbine ship than with the reciprocating one. At full power of 21.56 knots, the costs in heat units for the two vessels are approximately the same, namely, about 385,000 B.T.U.'s.

The above heat costs include all the engineers and the ship's auxiliaries. The North Dakota is not brought into this comparison, as in the measurements of water consumption on that vessel only the engineer's auxiliaries were included.

This equality of heat cost at full power existing for battleships of 21 knots' speed, it is not readily seen how a saving of 15 per cent. in boiler weights, as has been claimed, can be made by the adoption of turbines for main propelling machinery in such cases.

Cruising Economy.

As pointed out above, the Utah at 12 knots required the absorption of 19.4 per cent. more heat units by her boilers than did the

Delaware. Referring to equal speeds, and comparing the Utah's performance with those of the Delaware and the North Dakota, we obtain as propulsive coefficients the results given below:

Ship.	Speed.	S.H.P.	I.H.P.	Revs.	Per Cent.
Delaware	12	....	3,800	66½	69.70
North Dakota	12	3,750	4,076	140¾	61.32
Utah	12	3,800	4,130	172	53.18

The above results are all based upon acceptance trial results, and would be considerably modified in actual service, as was shown by the performances of the Delaware and North Dakota when cruising in company with the fleet.

The reciprocating engine ship in bad weather showed up as fully 20 per cent. better than the turbine ship, and in good weather at a slightly higher speed as nearly 44 per cent. better. These results were obtained on the cruise of the fleet to England and back home. In justice to the turbine it must be stated that the turbines of the North Dakota, when examined shortly after, were found to be in damaged condition, due to erosion and corrosion, although the vessel was a new ship just starting a cruise.

Points of Superiority Claimed for Turbine Machinery Over Reciprocating Machinery for Battleship Propulsion.

These are: 1. Capable of being driven for long periods of time at high powers without the liability to derangement which exists with reciprocating engines.

2. Less work required to keep them in condition, and therefore decreased engine-room force.

3. Less vibration and, therefore, resultant better gun pointing.

4. Decreased boiler power necessary to develop power required for full speed.

5. Less total floor space necessary for engines and boilers.

6. Greater economy in oil and fuel at full power.

7. Greater economy in oil at cruising speeds.

8. Greater cleanliness of engine-rooms.

9. Greater capacity for overload.

10. Greater ease of repair.

11. Maintenance of original economy due to no increase of steam leakages from wear.

Let us take these claims, item by item, and see whether they are justified by actual experience.

called for are within the capacity of the ship's force, and the ship can remain on her station while the repairs are being made; in other words, turbine sickness usually requires hospital treatment, while the reciprocating engine can be cured by home treatment. Furthermore, there is as much difference between the two types when they are out of order as there is between an animal and a human being. Both give indications of being under the weather, but the reciprocating engine tells you where the trouble exists, while with the turbine you know that something is wrong inside, but what is wrong is known only after the hospital surgeons get to work.

As to the decreased engine-room force, our turbine battleships carry and need just as large a force as do the reciprocating ships of the same class.

3. As to vibration, where the reciprocating engine is well balanced and is mounted on a heavy, substantial hull, such as that of a battleship, the vibration is barely noticeable, and in the case of the Delaware and North Dakota, there appeared to be fully as much vibration caused by the propellers with the turbine vessel as there existed with the Delaware. Furthermore, if gun pointing be taken as a means of vibration, it is pointed out that the Delaware has just won the battle-practice trophy, beating out her turbine-propelled sister quite badly.

4. As for claim 4, it has been shown that with turbines for the designed full speed of the vessel a considerable increase in power over that required with reciprocating engines is made necessary by the decreased propulsive efficiency of the propellers. When turbine propulsion first became an accomplished fact, in all reports of trials great stress was laid upon the fact that the water consumption per hour per S.H.P. of the turbines was very considerably less than that per I.H.P. with reciprocating engines, but the great difference between the propulsive efficiencies of the propellers was not mentioned, this great inferiority of the turbine propeller for battleship work practically requiring the same amount of boiler power to be fitted for turbines as for reciprocating engines.

5. This claim is not justified, as Curtis turbine installations require approximately the same space, and Parsons turbines with cruising turbines more floor space, than is required for a reciprocating engine installation for the same speed of vessel.

6, 7, 8. Claim 6 is correct so far as lubricating oil is concerned, for with forced lubrication of reciprocating engine and with an open-

top oil casing, oil is thrown on the lower cylinder heads, where it vaporizes and is lost. The saving of fuel claim does not exist. Claim 8 is correct, but only at high powers. To offset these claims the working platforms of reciprocating engine installations are much more habitable on account of lower temperature.

9. This claim is justified only by the fact that turbines are not designed so close to the power requirements as are reciprocating engines. The steam areas through the blading are much larger than are necessary for the passage of the steam required for the designed power at the designed pressure. This criticism applies more particularly to turbines of the Parsons type.

11. This claim is a fact so far as the claim for no increase in leakage of steam is considered, but it can hardly be called an advantage over the reciprocating engine, as with proper care and experience the valves and pistons of the latter machine can be kept as tight throughout their service as they are the day they are put in commission. To offset this turbine claim we have the following troubles to encounter: excessive corrosion of rotors, which destroys balance, unequal expansion of rotors and of rotors and casing, which destroys clearance and results in destruction of blading, clearance troubles due to wearing of turbine and thrust-bearings, and the necessity of micrometer adjustments of these bearings to maintain clearance.

Vessels of High Power and Speed, Such as Battleship Cruisers, Scouts, and Destroyers.

When powering such vessels as the above, the power required for the high speeds becomes very great, and in order to confine ourselves to units of light weight, it is necessary to divide the power between two, three, or four shafts. Should reciprocating engines be used, they would be designed for a high number of revolutions and high piston speeds, and would thus become much more liable to derangement than are the comparatively slow-running, massive engines of the ordinary Dreadnaught battleship. In such cases we turn to the turbine as the rational power-producer, and up to date for such purposes the turbine is the machine par excellence.

In our service the battleship cruiser does not yet exist, our extra-fast vessels at present consisting of 3 scouts and 34 destroyers built and building.

As already stated, one of the scouts is fitted with reciprocating engines. She has done very good service, and below 21 knots has

been considerably more economical than her sister ships. Above that speed the turbine ships have the advantage, the percentage advantage increasing as the speed increases above 21 knots. As with these types of vessels high speed is the prime requisite, and economy at cruising speeds, while desirable, but still only a secondary consideration, no hesitation is met with in discarding the reciprocating engine as the primary propelling machine and taking up the turbine in its place.

With the Parsons turbine in these fast vessels the power is usually divided between three or four shafts, additional turbines for cruising at low and moderate speeds being fitted. These cruising turbines have been the cause of the major part of our troubles with the Parsons type; probably 90 per cent. of the blade strippings which have occurred have happened in these turbines, and have usually taken place when the injured rotor was running idly in a vacuum. In the latest destroyers, in order further to increase the cruising economy and to escape the blade troubles of the cruising turbines, these last-named turbines have been omitted, and small, rapid-running reciprocating engines installed in place of them. These engines are designed for about 350 revolutions, and are fitted with forced lubrication, the working parts being inclosed in an oil casing. They remain in operation, exhausting through the H.P. turbine until the speed reaches about 16 knots. Above this speed they will be disconnected, and the main turbines only will be used, the H.P. turbine being fitted with a couple of cruising stages for use in producing speeds from 16 to about 25 knots.

This cruising reciprocating engine has been also fitted, one engine on each shaft, to two shaft arrangements, where the Curtis or the Zoelly turbines are used as main propelling engines. With such an arrangement, however, the cruising engines are an additional weight over the already quite heavy weights of these impulse turbine units, and the advantages gained will have to be considerable to justify their retention.

The main point of difference in the different designs of these combination systems is in the designed exhaust pressure from the L.P. cylinder of the reciprocating engines to the inlet nozzle of the turbine, and the stage of the turbine at which this exhaust steam is admitted. It may be accepted as an axiom that "the higher the exhaust pressure from the engine to the turbine, the greater will be the range of speeds through which the combination will hold its superiority over the straight reciprocating or the straight turbine drive."

Economy and Ruggedness of the Different Types of Turbines.

Remarks under this head can be summed up in a very few words as follows: Considerable trouble has been experienced with Parsons turbines, due to stripping of blades through loss of clearance, while, since an initial fault in the L.P. blading of the Zoelly turbines of the Warrington and Mayrant has been corrected, blading troubles with the Curtis and the Zoelly turbines are practically unknown. These latter classes, due to their greater blade clearances, do not require the accurate adjustment that is absolutely necessary with the Parsons turbine, and from this fact is reaped a decided benefit in service. As to the relative economy of propulsion of the three types, the question is involved by the use of various designs of boilers with the different types. Results appear to indicate, however, that there is little difference between them, with the balance slightly in favor of the impulse reaction type.

Leaving the subject of main propelling engines, we will now describe the most important departure from early practice that has been made in late years; this is, the adoption of oil as a fuel.

Oil Fuel System of the Navy.

In adopting oil fuel for the naval service, the first thing necessary was to decide upon that system of atomization of the fuel which was best adapted to our needs and conditions. The system to be adopted must be one which would entail no loss in fresh water and the minimum additional weight possible.

The very conditions of the problem forced the department into the search for a satisfactory method of mechanical atomization. By adopting such a method no loss of fresh water would occur and no air compressors were required. The only additional weights required with such a system were those of the necessary oil pumps, piping, and burners.

After investigating the field available, the method of mechanical atomization, as developed by the Schutte-Koerting Company, was decided upon as the most promising for a foundation on which to build, and this system was adopted.

Description of the System.

The system as developed for use in the naval service really could be classed as "Oil Fuel Burning Reduced to the Simplest Form."

The problem of air admission is of the greatest importance, as if it is improperly done, smokeless combustion becomes nearly an impossibility, and the burning of oil at a high rate of combustion becomes accompanied by a series of pulsations of such magnitude as to cause the boiler casings to pant and the brick linings to break loose and fall.

Oil-burners.—These are of the simplest character, and consist of an oil-pipe with a cast piece screwed on the end and forming the tip. The opening in the tip varies from 1.5 mm. to about 2.3 mm., depending upon the maximum amount of oil to be burned. Inside of this tip casting is a whirling chamber to which the oil is admitted in such a manner as to give it a rapid whirling motion around the axis of the burner. This causes the oil issuing through the tip opening to fly off tangentially as soon as free from the burner, and produces an intimate mixture of the oil with the air entering through the cone around it.

The oil burns without noise and produces a beautiful lance-head flame, nearly white in color. The combustion, by giving a slight excess of air, can be made absolutely smokeless, but the vessels usually operate with a slight haze issuing from the smoke-pipes, as by so doing they can regulate closer to maximum efficiency conditions than if no smoke is showing.

Oil Fuel for Battleships.

The first installations fitted to battleships and, in fact, the only installations until the plans of the Nevada and Oklahoma were developed, were for boilers primarily fitted for burning coal as the regular fuel, the oil fuel being used only as an emergency aid in maintaining the required steam when it became necessary to bring coal from remote bunkers to the fire-rooms in use.

The same system of atomization as already described is fitted, the burners being located between the furnace doors of the boilers.

On account of the difficulty of maintaining the necessary triple balance between oil, coal, and air supply, the results obtained are not as satisfactory as when burning either oil or coal alone. The first installations were rendered still more unsatisfactory by the reluctance of the boiler manufacturers to so modify the designs of the furnaces and furnace fronts as to meet the demands of the new conditions.

The necessary changes have, however, gradually been realized, and in the Florida, Wyoming, and Arkansas we have practically identical conditions of air admission for the oil as exists in boilers

for oil burning only, while in the Texas and New York, in addition to having this same system of air admission, the furnace volumes have been very considerably increased.

In the case of the latest design, the battleships Nevada and Oklahoma, the department has made a radical departure, and, so far as fuel is concerned, boilers and method of burning the oil, the vessels have become gigantic destroyers.

By adopting oil as the only fuel for these vessels the fire-room weights have been decreased about 360 tons, the necessary fuel weight for the designed cruising radius decreased in about the proportion of 9 to 7, the fire-room force decreased fully 50 per cent., while the total length of the ship required for boilers and fire-rooms has decreased from 128 feet to 66 feet.

Evaporation with Oil Fuel.

The evaporative results obtained by the use of oil fuel with mechanical atomization are quite good, as can be seen from the following table:

Name of Vessel.	Minimum Power.		Maximum Power.		Type of Cone and Burner.
	Lbs. Oil per Sq. Ft. H.S.	Water per Lb. Oil.	Lbs. Oil per Sq. Ft. H.S.	Water per Lb. Oil.	
Trippe	.0754	12,787	.895	11.905	Normand.
Paulding	.147	10.85	.951	11.9	"
Drayton	.132	12.88	.965	10.77	"
Perkins	.153	12.03	.911	10.34	Fore River.
Sterett	.157	11.81	1.012	10.427	"
Walke	.0827	13.20	.79	12.94	"
McCall	.136	12.579	.785	12.31	Schutte-Koert.
Burrows	.134	12.865	.755	12.937	"
Ammen	.096	10.541	.848	11.989	"
Warrington	.196	10.046	.993	10.446	S.K.-Peabody.
Mayrant	.12	11.584	1.02	11.126	"
Patterson	.088	12.582	.707	14.009	"
Terry	.147	11.95	.984	11.678	Thornycroft.
Monaghan	.108	11.349	.917	11.654	"

From this table we see that the average evaporation from actual boiler conditions for low rates of combustion was 11.91 pounds at an average feed temperature of 155.6° F. and an average boiler pressure of 238 pounds per gage, no correction for the quality of the steam being made.

For high rates of combustion these figures become 11.745 pounds, 163.5°, and 257.16 pounds pressure, respectively.

Estimating that the steam will be dry at the low rates of combustion, and that at the high rates there will be about 3 per cent. of moisture, the evaporations under the two conditions reduced to "from and at 212°" become—

For low rates of combustion, 13.23 pounds.
For high " " " 12.58 "

The above results are the average under trial-trip conditions, and were obtained with "Express" type boilers, which are unquestionably inferior to some other types. It is further worthy of notice that, as the trial-trip crews became more accustomed to the management of oil fuel, the results became better.

The results obtained with the mechanical system of atomization, burning oil under a Babcock and Wilcox boiler, with the Peabody burner and air register, as reported in the "Journal of the American Society of Naval Engineers," were as follows:

Lbs. Oil per Sq. Ft. H.S.	Lbs. Water Evap. per Lb. Oil from and at 212° F.	Equiv. Lbs. Coal per Sq. Ft. G.S. per Hour
.259	15.86	16.13
1.56	13.7	75.34

The boiler efficiency at the low rate of combustion figured out as 80.21 per cent. and at the maximum rate as 69.29 per cent.

Conclusion.

The advance of the service has not been confined solely to improvements in the main propelling engines and in the adoption of oil as a fuel, but there has been a general advance all along the line, such as in the adoption of forced lubrication to all reciprocating engines, both large and small; in the adoption of electric-driven blowers for large vessels, and of turbine-driven blowers for destroyers; in improvements in condensing apparatus, feed-heaters, pumps, evaporating and distilling apparatus; in fact, a close watch has been kept on every item of machinery, both in its design and its operation, in order that the vessels of the navy should be maintained at the highest point of efficiency, and that the dollars of the public should be spent in such a manner as would return to the public the greatest value for the money expended.

lected too long to effectually stem the trend toward marine turbine development, and therefore it was in the direction of the later type of installation that the maritime world began to look for that progress and advance which were demanded by the army of trans-Atlantic tourists and by naval interests. While the demand for continuous high speed was too persistent to wait upon the progressive development of the reciprocating type, it is extremely probable that, if the same energy, research work, and financial outlay that had been expended in developing the marine turbine had been used in improving the reciprocating engine, the extent of the turbine installation now afloat would be but a fraction of what is in existence.

The research work, patience, and engineering talent devoted to the development of the marine turbine was of world-wide benefit, and the special work of Sir Charles A. Parsons undoubtedly places him in the front rank of the world's great inventors. The invention, however, of the expanding nozzle by DeLaval probably constituted the one important and distinct feature of turbine advance that contributed most to the scientific development of the art.

Limitations as Regards Turbine Installation.

As Captain Dyson states, the machinery installation par excellence for destroyers, scouts, and vessels demanding continuous high speed is that of the turbine design. The anticipated economy, even at high speed, of such vessel has not, however, been obtained. This is due in great part to the inefficient propulsive effect of the propeller when operated at the high speed that is a concomitant of the direct-driven turbine. At low speed the existing marine turbine installation is well known to be an exceptionally wasteful appliance. It is exceedingly doubtful, however, if either Parsons or Curtis ever intended their design of turbines to be installed in any other type of ships than those which were to be operated at continuously high speed. The limitation of the direct-driven turbine as regards economy was well known to naval engineers even before a single trans-Atlantic steamer was fitted with such an installation.

Incidental to this phase of the subject I might state that in 1904 I was invited by Mr. George Westinghouse to make a careful study of the marine turbine situation in Europe, and to that end I spent over four months with my late partner, Mr. John H. Macalpine, in a study of the subject. Unusual opportunities for securing reliable information as regards turbine development were given us. The thoughtful views of many leading continental authorities upon the turbine were likewise obtained. The result of this investigation was embodied in a report dated May, 1904, wherein the following conclusions were stated:

> "We have already stated that we have been led to believe it would be injudicious to apply the turbine to other than very fast ships which have to run a very small proportion of their time at cruising speed; and even in the case of fast ships the advantages have been far overstated.
>
> "If one could devise a means of reconciling, in a practical manner, the necessary high speed of revolution of the turbine with the comparatively low rate of revolution required by an efficient propeller, the problem would be solved and the turbine would practically wipe out the reciprocating engine for the propulsion of ships."

Contrary to the views of many thoughtful naval engineers, and probably in opposition to the advice of the several inventors, turbines were installed in vessels

it is well known in engineering circles that the coal consumption of this vessel on a round-trip voyage between New York and New Orleans was about 50 per cent. in excess of that of the sister ships Comal and Antilles, vessels of the same tonnage and fitted with reciprocating engines. The Creole was never able to develop the speed that was secured by her sister ships. There was an effort made to ascribe the inefficiency of the Creole turbine installation to the fact that this ship was fitted with water-tube boilers; but in refutation of this statement it is only necessary to tell that with an installation of reciprocating engines replacing the turbines, the Creole, with the same boilers, was brought up to the high efficiency of her sister vessels Comal and Antilles.

It is common knowledge that in some of the trans-Atlantic steamers fitted with turbines it has been found necessary to install additional bunker facilities in order to insure a reliable coal-supply for other than a fair-weather voyage. The trans-Atlantic vessels fitted with reciprocating engines, as a rule, reach port with at least two or three days' reserve of coal in their bunkers.

The turbine-driven vessels are well known to have a much smaller reserve, and this fact affords quite conclusive testimony that the efficiency results of the marine turbine are considerably less satisfactory than were expected. This is a subject of exceeding importance to the traveling public, and it would appear as if this matter is a problem deserving of special investigation by national authorities. Should there not be some legislation whereby no trans-Atlantic steamer should be allowed to engage in passenger service unless her coal-bunker capacity was of such volume as to contain at least two days of reserve coal beyond that required for the ordinary winter passage?

Wide Divergence in Efficiency Between Land and Marine Turbines.

There is a marked, even radical, difference in the performance of turbines designed for power stations on shore as compared with the installations required for marine purposes. The shore turbines are operated at a constant speed and variable power. The marine installation must be operated at both variable power and variable speed. The shore installations are usually designed to give a high steam economy at full load with nearly an equally good steam rate at 150 per cent. of full load. For naval vessels which cruise mostly at moderate speed it has been found that the direct-driven turbine is very costly to operate when running under medium speed condition.

In the land installation of turbines there are substantially no limitations as regards height, floor space, and weight to be encountered. The designer is not compelled to take into consideration the problem of propeller efficiency. In the discussion of the marine phase of the matter the efficiency of the land installation cannot be used as a criterion. In marine work the boiler designer is also subjected to all manner of limitations, and therefore the steam supply to the marine turbine can be obtained only at greater expense than the cost of supply to the shore turbine.

The Necessity for an Efficient Installation of Reduction Gear for Marine Turbines.

Among the first American firms to acquire the right to manufacture the Parsons turbine was the Westinghouse Machine Company. The detailed plans of

frame to carry the pinion shaft. Mr. Westinghouse undertook the construction of this experimental gear. From the first the arrangement was quite successful. After effecting minor changes in the original design the experimental gear transmitted for long periods about 6000 horsepower, with a loss in energy of only 1.5 per cent.

Original Difficulty in Cutting the Gearing.

It may be interesting to know that when the original design was made for this reduction gear there was no machine-shop in the country that could or would guarantee the reliable cutting of gear of the size required. The gears desired were 72 inches in diameter, 22 inches face, and with a pitch of 1¼ inches. The pinions were to be 14 inches in diameter. Both gears were to have an angle on the face of 30 degrees. The distance between the centers of the gears was to be 4 feet, in order to make room for a middle bearing on the pinion shaft, so as to prevent springing of the shaft, and thus avoid consequent non-alinement of the gears.

Several bids to build a machine that would cut these gears were received from different firms. One company offered to build a tool and cut the gears for $16,000. No American firm, however, would guarantee the necessary accuracy of cutting. Finally a contract was made with Schuhardt and Schutte, of Berlin, Germany, to build a machine and cut the first set of gears required. The cost of this machine was $8,500, and the price of cutting the first set of gears was $800. The forgings were made by Krupp, of Essen, Germany.

The firm of Schuhardt and Schutte guaranteed the accuracy of the teeth to $\frac{1}{1000}$ part of an inch. I regret to say this degree of accuracy was not realized, and it took considerable time to scrape the teeth to true bearing. This was due to a considerable extent to the springing of the machine. Mr. Westinghouse's experts, however, found that, by strengthening the frame of the machine and by cutting the worm driving gear in two parts, then turning the worms on their axes and recutting new hobbing tools, all inaccuracies were eliminated. At the present time all gears are so accurately cut with this arrangement that the gears can be removed from the machines and put to immediate service.

The same may be said of all smaller gears that are being cut by the Gould machines manufactured in Newark, N. J. They are turning out perfectly true gears, but only for smaller machines, such as are used for single-phase dynamos, centrifugal pumps, and for other appliances manufactured by the Westinghouse Company.

Five years ago, therefore, there was no gear-cutting machine in the country that could cut such gears with a fair degree of accuracy, and even the imported machine fell far short of its guarantees. Happily, now, through the efforts of the engineers of the Westinghouse Machine Company, gears of the largest size can be cut, placed in the frames, and set to work without having any scraping or fitting required to the teeth.

It is but just, however, to Messrs. Schuhardt and Schutte to state that the reason of the inaccuracy of their work was due more to the springing of the machine than to its design. But it is more to the credit of Mr. Westinghouse that he undertook the work of developing this tool to make it adaptable for practically any work within the capacity of the American machine-tool maker.

Section of frame 89 looking forward.

Exhibit H, showing proposed complete emplacement of four turbines and two reduction gears for twin screws, U.S.S. North Dakota: H.P. each turbine, 7500; H.P. total for ship, 30,000; Rev. P.M. turbines, 1,500; Rev. P.M. Propeller, 150.

out to its bottom and a 14-inch piston placed therein, in which, at a depth of 77 feet below the curb, or 37 feet below ground-water, the piston supported 28 tons without further settlement, after an initial settlement of about 2¾ inches; while under a load of 15 tons the following observations were made, the material being ordinary sand:

Load.	Depth below Water.	No Further Settlement after the Initial of
15 tons per square foot	10 feet ±	¼ inch
15 " "	20 " ±	½ "
15 " "	37 " ±	0.37 "

While not conclusive, this test would tend to show that depth does not necessarily add to the stability of ground.

Tests have also been made on a 14-inch hollow pile in firm water bearing gravel, in which a measured circumferential area of 6½ square inches resisted a measured load of 60 tons, with no initial observed settlement.

Conclusions follow that any foundation on firm ground, deep enough to be guarded against and protected from lateral displacement, can be compacted by ramming or by driving short piles into it, or, if possible, by subjecting it to excess weight, to avoid the usual initial settlement due to compacting, and that it will then, without further settlement, resist pressure greatly in excess of that usually allowed.

Before concluding, the writer desires to note a few observations and reasons for his belief that the general principles outlined in this paper are true. In the first place, it is assumed that ground pressures are not subject to the same laws as aqueous pressures. If this were not true, it would be impossible to excavate deep trenches or tunnels, even in dry ground, without air-pressure. Not only is it possible to work safely at great depths in tunnels and trenches, but any one familiar with such work must realize that the bottom or floor of a deep tunnel or trench exposed for a large area shows no evidence of pressure in normally dry ground. The fact that pressure is not transmitted directly to the exposed bottom should be conclusive proof that arching action does exist in earth. It is also true that coffer-dams can be sunk to great depths in coarse sand or gravel adjacent to deep bodies of water by means of pumping, *i. e.*, without air-pressure, showing that the presence of water alone does not give aqueous properties to some materials. If, then, the arching action of normally dry earth exists to some degree,

The Engineers' Club of Philadelphia

1317 Spruce Street, Philadelphia, Pa.

Annual Report of the Board of Directors

FOR THE FISCAL YEAR 1911

JANUARY 27, 1912.

TO THE MEMBERS OF THE ENGINEERS' CLUB OF PHILADELPHIA:

The Board of Directors herewith presents its report for the year ending December 31, 1911, as follows:

Eighteen stated and four special meetings of the Club were held, at which the maximum attendance was 300 and the average 101. Nine regular, two adjourned, and one special meeting of the Board of Directors were held.

The summary of membership on December 31, 1911, as compared with the summary of December 31, 1910, is as follows:

	1910			1911		
CLASS.	Resident.	Non-resident.	Total.	Resident.	Non-resident.	Total.
Honorary	2	2	4	2	2	4
Active	367	97	464	361	92	453
Associate	56	5	61	59	7	66
Junior	49	10	59	52	12	64
	474	114	588	474	113	587

Seventeen Active, eight Associate, and twenty-one Junior Members were elected; two Associate Members were transferred to the Active grade, four Juniors to the Active grade, and seven Juniors to the Associate grade; one Associate and five Active Members died; thirty-one Active, five Associate, and five Junior Members resigned; two Associate Members were dropped from the rolls, and two Active Members were reinstated to membership.

The record of deaths is:

J. Roosevelt Shanley, Active Member, died August 25, 1910.
Heber S. Thompson, Active Member, died March 9, 1911.
Francis Schumann, Active Member, died June 29, 1911.
Howard Wood, Active Member, died July 1, 1911.

James Christie, Active Member, died August 24, 1911.

Alexander G. Sparks, Associate Member, died October 24, 1911.

The following papers have been presented before the Club:

JANUARY 7.—"New York City's Additional Water Supply from the Catskill Mountains." Thomas H. Wiggin (Visitor).

JANUARY 13.—"Engineering Work of the Reclamation Service." F. H. Newell, Director of U. S. Reclamation Service.

JANUARY 21.—"The Functions of the Landscape Architect in Connection with the Improvement of a City." Thomas W. Sears (Visitor).

JANUARY 30.—"Esperanto: Its Benefit to the Engineer." Prof. A. M. Christen (Visitor).

FEBRUARY 4.—Annual Address—"The Beginning of Sanitary Science and the Development of Sewerage and Sewage Disposal." President William Easby, Jr.

FEBRUARY 15.—"The Engineering Features of the Panama Canal." Col. George W. Goethals (Visitor).

FEBRUARY 18.—"The Superstructure of the Passyunk Avenue Bridge." Henry H. Quimby (Active Member).

MARCH 4.—"The Design of Impellers of Modern Centrifugal Pumps." N. W. Akimoff (Active Member). "Engineering Features of Electric Furnaces." Carl Hering (Active Member).

MARCH 18.—"A Review of the Progress of City Planning." B. A. Haldeman (Active Member).

APRIL 1.—"The Atlantic Coastal Project." J. Hampton Moore (Visitor).

APRIL 15.—"The New York State Barge Canal." William B. Landreth (Visitor).

MAY 6.—"The Principles of Scientific Management." Frederick W. Taylor (Visitor).

MAY 20.—"The Forty-second Street Bridge in Philadelphia." Henry H. Quimby (Active Member).

JUNE 3.—"The United States Fuel Testing Plant." S. B. Flagg (Visitor).

SEPTEMBER 16.—"The Sanitary Supervision of the Catskill Aqueduct." Dr. David S. Flynn (Visitor), Sanitary Expert of the Catskill Aqueduct Commission.

OCTOBER 7.—"Gas Production, with Special Reference to the Manufacture and Distribution of Illuminating Gas in Cities." C. J. Ramsburg (Visitor).

October 21.—"The Failure of the Austin Dam." John W. Ledoux (Active Member).

November 4.—"The Present Activities and Progress of the Coast and Geodetic Survey." Prof. O. H. Tittmann, Superintendent of the U. S. Coast and Geodetic Survey.

November 18.—"The Theory of Earth Pressures." J. C. Meem (Visitor).

December 2.—"Reclamation Engineering in Russian Turkestan." Arthur P. Davis (Visitor), Chief Engineer of the U. S. Reclamation Service.

December 16.—"The Water Power Plant of the City of Sturgis, Mich." Prof. Gardner S. Williams (Visitor).

Two social entertainments were held during the year. A reception and dance was held on April 24, 1911, the expenses of which were met by subscription, and a smoker on November 11, 1911, the expenses of which were defrayed from the Club funds. Both of these functions were well attended and successful in every way.

FINANCIAL REPORT.

Following is the report of the Treasurer upon the finances of the Club. It will be noted that the statement of Income and Expense for the year shows the very creditable gain of $2308.15. The Building Fund notes have been reduced from $9500.00 to $8100.00, and one $500.00 second mortgage bond has been retired and cancelled. The finances of the Club, therefore, are in excellent condition.

STATEMENT OF ASSETS AND LIABILITIES AS AT DECEMBER 31, 1911.

ASSETS.

Cash—Colonial Trust Co.—Active Account	$409.38	
Colonial Trust Co.—Interest Account	1,572.50	
In Office	213.70	
		$2,195.58
Accounts Receivable Members' Ledger		3,626.61

INVENTORY OF SUPPLIES ON HAND.

Wines and liquors	$262.51	
Cigars	195.57	
Fuel	18.20	
Restaurant provisions	103.19	
	$579.47	
Carried forward		$6,401.66

Brought forward		$6,401.66
PROPERTY.		
Building No. 1317 Spruce Street	$72,850.00	
Furniture and fixtures—house	8,750.00	
Furniture and fixtures—restaurant	1,200.00	
Library	2,100.00	
		84,900.00
INSURANCE.		
Perpetual on Club House	$1,782.00	
Unexpired on furniture	7.86	
		1,789.86
MISCELLANEOUS.		
Bonds deposited by the Link Belt Company		1,000.00
Sinking fund for bond redemption		33.20
F. H. Stier, Treasurer		75.28
Total assets		$94,200.00
LIABILITIES.		
Accounts payable		$2,978.53
Bills payable—building account		8,100.00
Bills payable		1,500.00
First mortgage	$40,000.00	
Second mortgage bonds	26,250.00	
		66,250.00
Accrued interest—first mortgage	$1,080.00	
Accrued interest—second mortgage bonds	1,572.50	
		2,652.50
Reserve for bond redemption		33.20
Link Belt Company Fund		704.58
Reserve for redemption of Link Belt bonds		295.42
Appropriation from Junior Section to Library Committee		203.49
CHRISTMAS FUND.		
Balance, January 1, 1911	$33.00	
Contributions, December, 1911	277.00	
	$310.00	
Disbursements, December, 1911	250.00	
		60.00
Total liabilities		$82,777.72

Brought forward			$82,777.72

SURPLUS.

Surplus as at January 1, 1911		$7,989.13	
Transfer of initiation fees from bond reserve		625.00	
Cancellation of second mortgage bond		500.00	
Gain for year 1911 as per statement of income and expense		2,308.15	
Surplus as at December 31, 1911			$11,422.28
			$94,200.00

STATEMENT OF INCOME AND EXPENSE, YEAR ENDING DECEMBER 31, 1911.

INCOME.

Dues—net		$16,526.96	
Publications:			
Advertising directory	$520.00		
Advertising Proceedings	588.40		
Sales Proceedings	44.71		
Total from publications		1,153.11	
Miscellaneous:			
Interest on deposits	$18.37		
Badge sales	6.00		
Initiation fees	780.00		
Reprints	34.00		
Miscellaneous income	5.70		
Total miscellaneous income		844.07	
Club House Business:			
Restaurant sales	$7,222.28		
Wine sales	1,185.26		
Cigar sales	1,596.52		
Billiards and pool	191.55		
Lodging	3,063.58		
Rent of meeting-room	137.50		
Total income from Club House business		13,396.69	
Total income, year ending December 31, 1911			$31,920.83

EXPENSES.

Salaries and Wages:			
House salaries and wages	$2,922.96		
Office salaries	2,409.39		
Restaurant salaries and wages	3,815.51		
Total salaries and wages		$9,147.86	

Brought forward........		$9,147.86
Expense:		
House expense..........	$1,279.79	
Office expense..........	388.52	
Total expense..........		1,668.31
Publications:		
Directory publishing..........	$291.24	
Proceedings publishing..........	1,148.86	
Reprints..........	28.85	
Total from publications..........		1,468.95
Miscellaneous:		
Gas and electric light..........	$921.56	
Telephone..........	156.05	
Badge purchases..........	4.00	
Club luncheons..........	348.00	
Entertainment Committee..........	230.95	
Fuel..........	384.25	
Insurance..........	51.00	
Meetings Committee..........	503.68	
Membership Committee..........	101.50	
Taxes and water rent..........	943.00	
State tax on bonds..........	103.00	
Trustees of Bond Redemption Fund..........	3.00	
Suspense..........	49.59	
Total miscellaneous expense..........		3,799.58
Interest and Discount:		
Interest on first mortgage..........	$2,160.00	
Interest on second mortgage bonds..........	1,255.89	
Interest on Building Fund notes..........	363.68	
Discount on notes..........	7.75	
Total interest and discount..........		3,787.32
Club House Business:		
Restaurant purchases..........	$6,622.02	
Restaurant supplies..........	195.81	
Restaurant ice..........	192.88	
Restaurant laundry..........	216.01	
Restaurant renewals..........	12.97	
Restaurant equipment..........	156.21	
Cigar purchases..........	1,432.88	
Wine purchases..........	853.73	
Billiards and pool..........	35.10	
Total expense of Club House business..........		9,717.61
Carried forward........		$29,589.63

Brought forward				$29,589.63

INVENTORY, DECEMBER 31, 1911.

Wines	$262.51			
Cigars	195.57			
Fuel	18.20			
Restaurant provisions	103.19			
		$579.47		

INVENTORY, DECEMBER 31, 1910.

Wines	$251.23			
Cigars	65.00			
Fuel	66.00			
Restaurant provisions	89.14			
		471.37		
Deduct increase in inventory			108.10	
Total Club House business exclusive of salaries and wages			$9,609.51	

DEPRECIATION:

Furniture and fixtures—house		$41.40		
Furniture and fixtures—restaurant		29.59		
Library		.59		
Property		59.57		
Total depreciation			131.15	
Total expense, year ending December 31, 1911				$29.612.68
Net gain, year ending December 31, 1911				2,308.15
				$31,920.83

Respectfully submitted,

F. H. STIER,
Treasurer.

Audited and found correct.

STOCKTON BATES, C. P. A.,
For Stockton Bates and Sons.

We have examined this statement, prepared by the certified accountants, and believe it to be correct.

W. B. RIEGNER,
D. ROBERT YARNALL,
Auditors.

The following is the report of the Trustees of the Bond Redemption Fund:

Fourth Annual Report of the Bond Redemption Fund.

Being a Statement of Business for the Year 1911.

RECEIPTS.

Balance January 1, 1911	$403.39	
1–31 Initiation fees	105.00	
1–31 Repayment of expenses	4.50	
6–30 Interest on deposit	1.43	
		$514.32

EXPENDITURES.

2–10 Bond No. 205, at 95 per cent.	$475.00	
2–10 Accrued interest to 2–15–11	3.12	
6–19 Box rent	3.00	
		481.12
Balance		$33.20

Bond No. 205, par value $500.00, was purchased on February 10, in accordance with the rules, for 95 per cent. and accrued interest to that date. The bond and unmatured coupons were cancelled and delivered to the trust office of the Colonial Trust Company.

The Trustees hold no negotiable securities.

Henry Leffmann,
Edwin F. Smith,
Edgar Marburg,
Trustees.

We have examined the above account and believe it to be correct. The bank balance is of November 1, 1911, and is correct.

W. B. Riegner,
D. Robert Yarnall,
Auditors.

Respectfully submitted,

The Board of Directors,
Henry Hess,
President.
W. P. Taylor,
Secretary.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, January 6, 1912.—The meeting was called to order by President Hess at 8.40 p. m., with about 65 members and visitors in attendance. The minutes of the special meeting of December 9th and the business meeting of December 16th were approved as printed in abstract.

The following motion was presented by Mr. Robert Schmitz and carried: "That the Secretary be instructed to send a copy of the resolutions passed by the Club at the meeting of December 9, 1911, to each of the other engineering societies and clubs within the State, with the request that they take similar action."

Following a report of the tellers, the President declared the following elected to membership: Active, Charles Chapman Anthony, George LaRue Thompson; Associate, Leroy Moody Lewis.

Captain C. W. Dyson, U.S.N., presented the paper of the evening, entitled "Propulsive Machinery and Oil Fuel in the U. S. Naval Service," which was discussed by Rear Admiral George W. Melville, U.S.N., Honorary Member of the Club, whose discussion was presented by Rear Admiral John R. Edwards, Inspector of Machinery in the U. S. Naval Service; Mr. Charles Gordon Curtiss; Mr. H. T. Herr, of the Westinghouse Co.; Mr. Lovell, Chief Engineer of the Fore River Ship and Engine Co.; Capt. Bryan, of the U. S. Naval Service at League Island Navy Yard; Mr. Charles Hewitt, Mr. E. J. Dauner, and others.

On motion of Mr. Hewitt a vote of thanks was extended to Captain Dyson and all who participated in the presentation and discussion of the paper.

On motion of Mr. Trautwine a unanimous vote of thanks was extended to President Hess for the magnificent lantern which he presented the Club as a Christmas gift, and which was used for the first time at this meeting.

Regular Meeting, January 20, 1912.—The meeting was called to order by Vice-President Hewitt at 8.30 p. m., with 122 members and visitors in attendance. The minutes of the business meeting of January 6th were approved as printed in abstract.

Two resolutions were read in abstract, and it was announced that they would be brought up for discussion at the following regular meeting of the Club.

Mr. Henry Japp, visitor, presented the paper of the evening, entitled, "Subaqueous Tunneling," which was discussed by Messrs. H. H. Quimby, S. M. Swaab, John C. Trautwine, Jr., and others. On motion of Mr. Swaab a vote of thanks was extended to Mr. Japp.

Special Meeting, January 27, 1912.—The meeting was called to order by President Hess at 8.30 p. m., with 75 members and visitors in attendance.

Mr. W. J. Barney, Deputy Commissioner, Department of Docks, New York

of memorial be adopted, was read, discussed, and, upon motion, unanimously indorsed.

Mr. H. Clyde Snook presented the paper of the evening, entitled, "The Development of Roentgenology," which was discussed by a number of members and visitors. Upon motion of Mr. Swaab a vote of thanks was extended to Mr. Snook.

BUSINESS MEETING, March 2, 1912.—The meeting was called to order by President Hess at 8.35 P. M., with 62 members and visitors in attendance. The minutes of the special meeting of February 10th, and the regular meeting of February 17th, were approved as printed in abstract.

Following a report of the tellers, the following were declared elected to membership: Active, William Likens Brown, Claude B. Hagy, William Tudor Price; Junior, Thomas M. Chance, Clarence W. Rodman.

Mr. Warren, of the Izard-Warren Company, presented a short paper descriptive of certain new features in surveyors' instruments made by that company.

Lieutenant Colonel Odus C. Horney, U.S.A., presented the paper of the evening, entitled, "Smokeless Powder and High Explosives for Military Uses," which was discussed by Messrs. Robert Schmitz, E. M. Nichols, W. P. Taylor, Henry Hess, H. M. Chance, Martin Nixon-Miller, and others. On motion of Dr. Chance a vote of thanks was extended to Colonel Horney.

BUSINESS MEETING, March 16, 1912.—The meeting was called to order by Vice-President Hewitt at 8.20 P. M., with 99 members and visitors in attendance. The minutes of the business meeting of March 2d were approved as printed in abstract. Mr. H. H. Quimby, Chairman of the Committee on Public Relations, presented the following resolution, which was unanimously adopted:

"*Resolved*, that it is the sense of this Club that the patent laws of the United States are in need of revision, in order to safeguard more completely and equitably the interests of both inventors and the public, and that to this end the President of the United States should be authorized by Congress to appoint a commission of competent persons to make a study of the subject and suggest such legislation as may appear to be wise and efficacious."

It was further moved and carried that the Secretary be instructed to transmit a copy of this resolution to Congress.

Mr. B. A. Haldeman, Chairman of a special committee appointed to represent the Club at a conference in the Mayor's office on "The Promotion of the Systematic Planting and Care of Shade Trees in the City," moved the adoption of the following resolution, which also was carried:

"*Resolved*, that the Engineers' Club of Philadelphia recommend that the sum of $50,000 be appropriated by Councils to the Commissioners of Fairmount Park, acting as the Shade Tree Commission of this city, to be used in encouraging and assisting the planting of shade trees in the streets of the city, and in maintaining such trees as now exist or may hereafter be planted."

Dr. John A. Brashear, of Pittsburgh, Pa., presented the paper of the evening, entitled, "Stellar Evolution," which was followed by short addresses by Professor Charles L. Doolittle and Professor M. B. Snyder. On motion of Mr. John C. Trautwine, Jr., the thanks of the Club were extended to Dr. Brashear for his extremely interesting and instructive paper.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

REGULAR MEETING, January 18, 1912.—Present: Vice-President Hewitt, Directors Mebus, Halstead, Kerrick, Worley, Cooke, Develin, Gilpin, Haldeman, the Secretary, and the Treasurer.

The question of auditing the Club accounts was brought up for discussion, and the two Club Auditors present stated that the informal audit they gave the Club books was neither fair to themselves nor to the Club. After discussion, it was agreed that the Auditors certify to the report for the current year, but that the Board of Directors propose an amendment to the By-Laws of the Club to the effect that a certified public accountant be employed for the annual audit.

The Treasurer presented his annual report of the finances of the Club, which was accepted and ordered to be printed.

The report of the Trustees of the Bond Redemption Fund was also read, accepted, and ordered printed.

It was ordered that the Committee on Delinquent Accounts be given power to act in the matter of collections.

The Chairman of the Finance Committee presented a report, recommending that the building-fund notes be retired in a manner exactly similar to that employed for the second-mortgage bonds. This report was approved.

The House Committee presented a report, which was ordered to be filed, and the matters therein referred to the House Committee to be appointed next year.

It was moved that a vote of thanks be extended to the Chairman of the Meetings Committee for his success in securing an exceptionally high standard of papers during the past year. It was also moved that a vote of thanks be extended to the Chairmen of the House and Publication Committees for their services to the Club.

Messrs. Thomas H. Griest and D. L. Britten were, upon request, transferred from Associate to Active membership.

The following resignations were read and accepted: Jerome W. Howe, Wm. F. Newbery, G. M. Sinclair, F. M. Cresson, Gordon Brandes, Lionel F. Levy, H. M. Geer, W. L. Haynes, Benjamin Franklin, and J. F. Hasskarl.

Messrs. J. W. Campbell and H. T. McGaughan were transferred from resident to non-resident membership, provided that a mailing address outside the thirty-mile limit of Philadelphia be given.

Letters from the Engineers' Club of St. Louis, asking for resolutions relative to patent laws, and a letter from the Philadelphia Chapter of the American Institute of Architects, recommending resolutions on the Lincoln Memorial, were read, and ordered to be brought before the next meeting of the Club.

A report of the special committee on ventilating the meeting room was read and ordered to be filed.

The following resolution was passed:

Resolved, that the thanks of the Board be presented to President Hess for the gift of a projecting lantern and microscope; and

Resolved, that a plate be purchased, setting forth the date of the donation and the name of the donor, and applied to the lantern.

ORGANIZATION MEETING, February 15, 1912.—Present: President Hess, Vice-Presidents Hewitt, Plack, Mebus, Directors Halstead, Cooke, Develin, Vogleson, Berry, Haldeman, Swaab, Yarnall, and the Secretary.

It was moved and carried that the second part of the resolution passed January 18th, resolving that a plate be affixed to the lantern, be rescinded.

The following resignations were read and accepted: L. H. Losse, H. E. Snyder, Thomas F. Smith, Wyllys E. Dowd, Jr., Thomas H. Griest, Sydney B. Strouse, St. John Chilton, Charles F. Thacher, Jr.

The deaths of Francis J. Drake and Charles I. Young were announced.

A letter from the Treasurer, relative to members delinquent in dues, was read and laid on the table until the following meeting of the Board. A report of the Committee on Delinquent Accounts was presented, the report adopted, and the Committee discharged with thanks.

The Secretary was instructed to put into immediate effect the recommendations of the Committee.

The following were appointed standing Committees for the coming year, the Chairman of each Committee to appoint one or two additional members from the membership at large to serve as associate members of the Committee:

House: F. K. Worley, W. L. Plack.
Meetings: S. M. Swaab, H. C. Berry.
Membership: Charles Hewitt, F. H. Stier.
Finance: J. A. Vogleson, David Halstead.
Publication: Charles F. Mebus, St. George H. Cooke.
Library: B. A. Haldeman, Richard Gilpin.
Publicity: R. G. Develin, E. J. Kerrick.
Advertising: D. Robert Yarnall, Percy H. Wilson.

The following were then elected by the Board to serve as Tellers and Auditors:

Tellers: E. J. Dauner, L. H. Kenney, G. Wise.
Alternate Tellers: C. A. Bockius, A. D. Morris, Charles Elcock.
Auditors: W. B. Riegner, J. H. M. Andrews.

The following were appointed a Committee to revise the rules governing the Board of Directors, and to report at the next meeting of the Board: Charles F. Mebus, S. M. Swaab, W. P. Taylor.

On motion the President was authorized to appoint a Committee of eleven on "Public Relations," this Committee to be authorized temporarily to increase its membership for specific purposes, six of the eleven members to be appointed from the membership of the Board. The following were then appointed members of this Committee: H. H. Quimby, Edgar Marburg, Henry Leffmann, John C. Trautwine, Jr., Edwin F. Smith, Charles Hewitt, W. L. Plack, Charles F. Mebus, S. M. Swaab, Henry Hess (ex officio), W. P. Taylor (ex officio).

The following were appointed a Committee to prepare and present to the Board at its next meeting suggested amendments to the By-Laws of the Club: Charles Hewitt, J. A. Vogleson, W. L. Plack.

It was moved and carried that a Committee of five be appointed to investigate the conditions of this Club, and similar organizations in other cities, and gather all possible information about the management of such organizations, and report at the regular meeting of the Board in May. Mr. Mebus was appointed Chairman of this Committee, the other members to be appointed by him.

The Committee on Increase of Membership and the Art Committee were continued.

The House Committee was authorized to sell the old lantern.

Regular Meeting, March 14, 1912.—Present: Vice-Presidents Hewitt and Plack, Directors Worley, Cooke, Gilpin, Vogleson, Swaab, Yarnall, and the Secretary.

The Secretary announced that the Auditors, the Tellers of Election, and the Alternate Tellers, with the exception of Mr. C. A. Bockius, had accepted appointment to these offices.

It was also announced that the Committee to investigate Club Organization was appointed by Mr. Mebus as follows: Charles F. Mebus, S. M. Swaab, F. K. Worley, D. Robert Yarnall, and W. P. Taylor.

The Secretary presented a report, showing the condition of the finances, and showing a net gain of $68.00 in the income and expense account for the first two months of 1912.

The death of Melbourne E. Davis was announced.

The resignation of J. A. Wolle was read and accepted.

The Chairman of the Membership Committee reported that W. P. Dallett and Robert T. Mickle had been appointed associate members of this Committee.

Richard Gilpin, Chairman of the Library Committee, presented a report relative to the indexing of the library, which was referred back to the Committee for further report at the next meeting.

In connection with the work of the House Committee, correspondence from Mr. Carl Hering and Dr. Owens, relative to spigots in the bath-rooms, was read and referred back to the House Committee for action.

A letter from Mr. Hess, relative to an appliance for ventilating the meeting-room, was read and referred to a special committee on this subject.

The special Committee appointed to represent the Club at a conference in the Mayor's office on the planting and care of shade trees in the city read its report, which was received. A resolution contained in this report was ordered to be read at the next meeting of the Club. The Committee was then discharged with thanks.

The report of the special committee appointed to revise the rules for the government of the Board of Directors was read and adopted, subject to a few changes in phraseology.

THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

OFFICERS FOR 1912

President
HENRY HESS

Vice-Presidents

Term Expires 1913
CHARLES HEWITT

Term Expires 1914
W. L. PLACK

Term Expires 1915
CHARLES F. MEBUS

Secretary
W. P. TAYLOR

Treasurer
F. H. STIER

Directors

Term Expires 1913	*Term Expires 1914*	*Term Expires 1915*
DAVID HALSTEAD	ST. GEORGE H. COOKE	H. C. BERRY
E. J. KERRICK	R. G. DEVELIN	B. A. HALDEMAN
PERCY H. WILSON	RICHARD GILPIN	S. M. SWAAB
F. K. WORLEY	J. A. VOGLESON	D. ROBERT YARNALL

STANDING COMMITTEES OF BOARD OF DIRECTORS

House—F. K. Worley, W. L. Plack.
Meetings—S. M. Swaab, H. C. Berry.
Membership—Chas. Hewitt, F. H. Stier.
Finance—J. A. Vogleson, David Halstead.
Publication—Chas. F. Mebus, St. George H. Cooke.
Library—B. A. Haldeman, Richard Gilpin.
Publicity—R. G. Develin, E. J. Kerrick.
Advertising—D. Robert Yarnall, Percy H. Wilson.

MEETINGS

Annual Meeting—1st Saturday of February, at 8.15 P. M.

Stated Meetings—1st and 3d Saturdays of each month, at 8.15 P. M., except between the fourteenth days of June and September.

Business Meetings—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

At East Avenue the grout retaining bulkheads were built of rubble in cement mortar about every 100 feet apart.

In removing the shields after they met the electric arc was used for cutting out the steel bulkheads, floors, and vertical girders of the shields—possibly oxyacetylene would have been better.

The air-tight bulkheads supporting the air-locks were made of concrete placed inside the bosom of the cast-iron lining, and embracing the flanges for 10 feet, taking in 4 rings. They were removed by drilling and wedging.

DISCUSSION

Solomon Swaab: Is it not fair to assume that if you eliminate the horses and use the motor the figures will change entirely?

A. Yes, the whole problem changes then.

TABLE

Material.	First Cost. Sq. Yd.	Expense per Year. First Period.	Average Expense per Yard per Year. Fifty Years.
Granite	3.50	0.294	0.270
Wood	3.50	0.308	0.274
Asphalt	2.00	0.208	0.164
Brick	2.50	0.224	0.199

In Brooklyn we have kept accurate costs from 1902, and we have a ten-year curve showing a very uniform cost. Asphalt is not a positive substance that you can tell how it is going to act. Paving fifteen years old cost 9 cents per yard per year. If you strike an average, there would not be so much difference between the Buffalo pavement and the cost of the Brooklyn pavement. In Buffalo there are records of repairs up to twenty years out of guarantee. They say there, however, that they have not had enough money to keep their pavements in proper repair, and that if they had a little more money, it would have cost perhaps 10 to 15 per cent. more than is shown.

A diagram received from the city of Washington shows a remarkable condition. The cost runs up to 2 per cent. for the first year under guarantee, being practically the same as Buffalo and Brooklyn; it then runs along up to 3, 4, and 5 until it gets to the nineteenth year under guarantee, and when the pavement is about twenty-four years old, to about 6¼ cents, which is the highest cost; from the nineteenth year on it begins to drop. The pavements out of guarantee twenty-nine years cost 2 cents a yard for repairs. It is a remarkable condition, but then Washington is a remarkable city—abnormal, I may say, in that respect. The streets are wide, the traffic is light, and the traffic is also fairly equable, and there is enough money to keep the streets in repair.

Mr. Swaab: Where you have 6, 7, 8, and 9 cents for maintenance, does that mean that you have maintained that pavement in its original form? Does it not depend upon what standard you use?

A. Absolutely; but in Brooklyn we have kept these pavements in absolutely good condition. In Buffalo they make the explanation that they might have spent 10 to 15 per cent. more. In Washington the pavements have been kept in good condition.

I have a scheme for determining at what time it was proper to relay an asphalt paving:

Let N = Life of proposed paving.
C = Cost per square yard.
I = Rate of interest.
R = Estimated cost of repairing if distributed over entire life.
A = Sinking fund to be paid each year to equal C at the end of N years.

X+C I+R/N = the annual expense of new paving.

If this annual expense is more than it is costing to keep the pavement in repair, it is not policy to relay it. Perhaps, by spending 15 cents a yard on a pavement this year, it might be put in such condition that next year it would be necessary to spend only five cents.

It seems to me that this is a scientific way to determine when to relay pavements; that is, for a sheet pavement. Granite cannot be determined in the same way.

Karri wood is used a little in New York, on Twenty-second Street near Fifth Avenue. It did not give satisfaction. Hard-wood pavements require almost no repairs in the first five years as compared with the soft woods.

Wm. Easby, Jr.—Are there any standard surface mixtures in use; that is, standards with reference to the grading of sand, amount of filler and bitumen used? Also, has it been possible to adhere to such standards?

A. We have been figuring on that to quite an extent this past winter. The real thing in asphalt is to have the right kind of bitumen; that is the thing which is absolutely necessary; then the grading of the sand is important, and also the filler, as you suggest. There is much questioning among engineers as to the grading of the sand. There are two schools—one believes in the fine mixture, and the other, in the coarser. I believe in the finer sand myself, and the more bitumen you can carry, the better your pavement will be and the longer it will last. For a heavy traffic street I think you should have from 11 to 11.5 per cent. of bitumen. I have forgotten exactly what the grading of the sand is, but I favor the use of that which will all pass a 10-mesh sieve. It is almost impossible to find a sand that will give a perfect grading, and the contractors, as a rule, use the best they can get in any locality. They mix it to get it right.

The construction of an asphalt street is a very difficult problem, and it is a strange fact that when the asphalt companies keep an accurate record, mechanically and chemically, of how they lay all their pavements, and then duplicate the best as nearly as possible, they do not get the same results.

The first asphalt pavement I had charge of was in Omaha, Nebraska, in 1882 and 1883. Omaha is about as difficult a place in which to maintain an asphalt pavement in as any in the country, as the natural sand grading there is bad. Omaha's summer temperature is from 140° in the sun to about 110° in the shade, and in winter I have seen it 30° below. However, that pavement referred to above was down for twenty-five years; it was laid by rule-of-thumb, and it was a better pavement than many laid today by scientific principles.

A few rules were used in Omaha thirty years ago. They are doing better now; but what I mean is that it is very hard to get the mixture just right. Asphalt is an artificial mixture and sometimes gets too hot; if the sand or the asphalt gets too hot, nobody knows anything about it, because the man in charge of the work knows enough, usually, to keep quiet. If the asphalt is good, and is laid with a good grade of sand under good conditions, it should not fail.

Q. Is there not less chance of burning the asphalt now with the steam coil?

A. Yes; and if you use the oil fuel, you can easily maintain the heat as desired.

W. H. Fulweiler.—With reference to the treatment of the wood block: you spoke of the proper kind of oil to be used. Is there any accelerated test by which you could determine to a reasonable degree the uses to which this oil could be put; that is, as to the complexity of the oil itself. Would you have to wait twenty years to be able to tell whether the oil was suitable or not?

PAPER No. 1111.

THE ENGINEER IN HIS RELATIONS TO THE CITY PLAN.

NELSON P. LEWIS

(Visitor.)

Read May 4, 1912.

A GREAT deal lately has been said about what is called city planning. Everything relating to municipal affairs has been very fully discussed, including accounting, budget making, 100 per cent. efficiency, commission government, and many other things which might be classified as ideas or idiosyncrasies, as facts or fancies. City planning has been the subject of local, State, national, and international conferences, conventions, and exhibitions, has been discussed in lectures, newspapers, periodicals, and books, and one quarterly publication is devoted exclusively to this subject. Such evidences of wide-spread interest could not well have been manufactured by those having some selfish interest to promote, but it seems quite clear that the public is becoming greatly interested in the subject. It cannot, therefore, be dismissed as a fad or as a matter that appeals only to theorists, but we must recognize it as something real and vital to the proper growth of our cities. In this paper an effort will be made to discuss the following questions:

1. What does city planning mean?
2. What are its economic advantages?
3. What progress has been made in city planning in this and other countries?
4. Who should be responsible for the city plan?
5. What general principles should govern city planning?

First, then—what is it? It is simply the exercise of such foresight as will promote the orderly and sightly development of a city and its environs along rational lines, with proper regard for the health and convenience of the citizens and for the commercial and industrial advancement of the community. It does not mean what has been so often called the "city beautiful." It does not mean or even include municipal art, nor does it, in the author's opinion, include the architecture of public or semi-public buildings.

A city planned in accordance with the principles laid down in the above definition will surely become beautiful; it will lend itself to artistic treatment (not adornment by municipal art, for it is difficult to explain in what respect "municipal" art differs from any other kind of art); it will provide adequate sites for public and semi-public buildings, which can be availed of by the architect when the time comes without the expense of rearranging the street system to give them a proper setting. To plan a city with its final artistic embellishment would be not only folly, but would be far beyond the capacity of any one man or group of men in any one generation. To attempt to designate the specific sites for future public buildings with a special regard to the size, shape, and design which those making the plan deemed to be most suitable would evidence an arrogance and self-complacency which would render one unfit for the task he has undertaken.

Reverting to our definition, the planning should include not only the city, but its environs—that is, it should bear some relation to the neighboring cities and the rural and small urban districts which are within easy reach. Every city is supported, to a large degree, by the country behind or about it. The idea that every effort should be made to confine its working population as far as possible within the red lines forming its boundaries is a fallacy having its origin in the selfishness of those who wish to maintain realty values within the city at as high a figure as possible. The object should be to reduce to a minimum the resistance to both intraurban and interurban traffic. This applies not only to ordinary street traffic, whether by vehicles or surface railways, but to steam and electrically operated railroads for the transportation of passengers and freight. The idea that railways are an evil which must be tolerated, but that they should be kept out of sight and should be compelled to carry on their business almost surreptitiously, is a grave mistake. A city cannot live, much less grow, without them. A city plan must, therefore, provide not only direct and ample thoroughfares for vehicular traffic and routes for the transportation of passengers to and from their homes within the city, but it must take into account the vital nec of railway lines and terminals for the economic and expedit ling of passengers and freight in such a manner as to as possible, the time and expense of transportation to office, shop, or factory, from and to points outside t

Thoroughfares should be both radial and c

every great city there is always one center of the first importance with a number of minor centers. The great radial thoroughfares will necessarily converge at the principal center, with minor radials reaching the subordinate centers, while the circumferential thoroughfares will connect the less important centers with each other and make it possible to go from one to another or to the suburbs without passing through points or districts of traffic congestion. The plans suggested almost simultaneously by Sir Christopher Wren and Sir John Evelyn for the rebuilding of the central portion of London after the great fire of 1666 illustrate this idea, but, unfortunately, neither plan was carried out. It is also shown, by the diagrams of radial and circumferential streets included in the report of the Metropolitan Improvements Commission of Boston, which shows how many links in such a system often exist, and how relatively simple a matter it is to supply the omissions. The possession of such a system of main thoroughfares would greatly simplify the problem of providing adequate transportation facilities, which most of our cities find so difficult of solution.

Regard for the health as well as for the convenience of the citizens requires that there shall be ample provision for open spaces for recreation and amusement. In other words, that there shall be, within easy reach of every home, a park where the occupants of that home can find fresh air and out-of-door rest or play. This does not mean that the parks must necessarily be large, that they should be highly developed by the landscape architect, or that they shall be located upon most expensive property. There are many tracts of land of varying sizes which are passed over by the real estate operator as unsuitable for development, and the cost of which would be very small, but which, if secured and held, would become extremely valuable to the public as parts of the park system of the future city. Nor need they be developed for years to come. A piece of natural woodland, a creek bottom now little more than a swamp, a rocky ridge or steep slope which is unavailable for building purposes, can often, by the building of a few paths or drains, be made to serve their purpose as playgrounds at slight expense. The important thing is to secure them while they are still cheap, with the right to dispose of or convert to other uses such portions of them as may not be desirable for park purposes when the city plan is finally developed. The idea which seems to have controlled the park policy of most American cities is that parks shall be located and purchased only when the actual

probable increase in demand and capacity to supply that demand. If the manufactory or the railway is foreordained to failure, the less spent upon it the better. There are a few towns which were laid out during "boom" periods on lines which were fancied to be those of a future metropolis, where the broad streets are grass-grown, where the public buildings are but half occupied, and where everything speaks of a splendid ambition which resulted in grotesque failure. When a city occupying a strategic geographical position has begun a natural development which causes growing pains indicative of a misfit in its general plan, it is time to look forward to adjust the plan to new conditions and to provide for still further growth. To tear down and enlarge is very costly—especially so when there is no room for enlargement without the purchase of additional land, which has become far more valuable than when the original enterprise was begun. This is constantly being done by individuals and corporations whose domestic or business requirements make it necessary. In every case it involves a distinct loss, which may be justified by means to indulge in a luxury or by the prospect of increased profit. Cannot the city, it may be asked, instead of trying to provide for the remote future, well afford the expense of reconstruction to adapt itself to its growing needs, especially when it has the power, through its ability to levy taxes and assessments, to impose the cost of necessary changes upon the property which will be chiefly benefited? No expense involving the destruction of property can be justified if it can be avoided by the exercise of reasonable foresight, and the taxing power of the city should not be used unnecessarily. The requirements of the modern city are so great that the burden of taxation will inevitably be heavy. Improvements in the city plan may increase values to such a degree that they would be cheap at almost any price, but if the plan can be so made as to avoid the necessity for destructive changes, both the city at large and the individual property-owner will be the gainers. To defer the correction of mistakes which are quite apparent in well-developed sections of the city, or to put off the adoption of a broader policy in those in process of development, because land is expensive and costly improvements would be destroyed, is not unnatural, even though it be unwise. To fail to take advantage of such object-lessons in parts of the city where there are few, if any, improvements, or where the street plan has not yet been fixed, is the height of folly. Every large city furnishes numerous instances of changes manifestly desirable but deferred until their cost has become prohibitive. To

show the money value of a good plan, not by forcing exaggerated values at some points, but by stimulating a healthy growth, through ease of access to all sections of the city, to schools, libraries, museums, parks, and playgrounds, it is only necessary to examine the successive annual assessment rolls of districts so favored. One specific instance will be given. During the sixteen years following the laying out of Central Park, New York, the average increase in the assessed value of real estate in other parts of the then city of New York was about 100 per cent., while in the three wards adjoining the new park the increase was approximately 800 per cent. Increase of population means almost invariably increase in wealth and taxable values. The most notable increase in urban population during the last quarter of a century has been in Germany. A comparison of the rate of growth of six American and a like number of German cities during the last thirty years will bear out this statement. These cities were selected at random by the author some years ago, simply because they had about the same population in 1880 and because they were believed to be typical. The increase by decades is shown in the following table:

Cities.	Pop. 1880.	Pop. 1890.	Per Cent. Inc. 10 Yrs.	Pop. 1900.	Per Cent. Inc. 20 Yrs.	Pop. 1910.	Per Cent. Inc. 30 Yrs.
Cincinnati . . .	225,139	296,309	16.1	325,902	27.7	364,463	42.8
Breslau	272,900	335,200	22.8	422,728	54.9	510,929	87.0
Buffalo	155,000	255,664	65.0	352,387	127.1	423,715	173.4
Cologne	144,800	281,800	94.6	372,229	157.0	513,491	254.6
New Orleans .	216,000	242,039	12.0	287,104	32.8	339,075	56.9
Dresden	220,800	276,500	25.2	395,394	79.0	546,822	147.1
Louisville	123,758	161,005	31.0	204,731	65.4	223,928	80.9
Hanover	122,800	163,600	33.2	235,666	91.0	302,384	146.2
Providence . . .	104,850	132,099	26.0	175,597	67.5	224,326	113.9
Nuremberg . .	99,519	142,523	43.2	261,022	162.3	332,539	234.1
Rochester	89,366	133,896	49.8	162,608	82.0	218,149	144.1
Chemnitz	85,000	138,955	63.5	206,584	143.0	286,455	237.1

It is generally conceded that the most scientific, painstaking, and far-sighted city planning done in recent years has been in Germany. While it may have been commenced for reasons somewhat sentimen and because of a striving for that beauty which had proved a va asset in the Latin countries, it has been continued because it to pay, and the German cities are fast becoming the most

the most orderly, and the most prosperous in the world. This is not a mere coincidence, but the conclusion is justified that scientific planning will promote, to a greater degree than has heretofore been realized, not only orderly development, but increase in population, wealth, and taxable values, to say nothing of the convenience, health, and comfort of the citizens. Many of the European cities have, on account of their antiquity, one great advantage in working out an admirable plan. A serious impediment to their growth has been the old fortifications within which the ancient cities were confined. It was fortunate for them that before they felt it safe to destroy the old walls and moats they had come to a realization of their value in affording sites for a splendid system of circumferential boulevards and open spaces. Perhaps the most conspicuous instance of this use is furnished by Vienna, whose superb Ring Strassen, occupying the spaces formerly devoted to the inner and outer fortifications, with its effective grouping of public buildings and its system of radial thoroughfares, make it, perhaps, the most beautiful of all cities.

In a brief reference to recent progress in city planning at home and abroad sharp distinction should be drawn between the ambitious and often spectacular plans to create civic centers with striking architectural features, and the less sensational, but often more important, efforts to correct, where possible, the present plan, and to provide for future development a scheme which will permanently fix the arteries of traffic and allow as great a degree of flexibility as possible in the filling in of details. The establishment of a civic center, such as that now in process of execution in Cleveland, but which is confined to a limited area, and the more comprehensive plan under consideration by Chicago, which extends over many blocks surrounding the proposed center, are certainly impressive. The former will, and the latter may, be worth while, whatever may be their cost. Their monumental dignity and beauty appeal strongly to the imagination and pride of the citizen, and the courageous optimism of the cities of the middle West and the Pacific coast may bring about their realization, although it will involve the destruction of costly improvements and the entire rearrangement of the street system in their vicinity. Memphis and Kansas City, which once may have been considered somewhat featureless, not to say commonplace, cities, have been developing park and boulevard systems which have already made them notable, and they are doing it because it has been found to pay. Los Angeles, Portland, and Seattle are working out plans

Upon the Local Government Board has been conferred authority formerly exercised only by Parliament itself, the latter retaining, however, certain veto powers. The area which may be included in a scheme is any land which is in course of development or which is likely to be used for building or for open spaces, roads, streets, parks, pleasure grounds, or incidental works, and may include land already built upon and even land not likely to be used for building purposes, if it is so situated that it ought to be included in the scheme. The Local Government Board may authorize a local authority to prepare a town-planning scheme if the Board is satisfied that there is a reasonable demand or call for such a plan. A scheme proposed and adopted by any local authority cannot become effective unless it shall first have been approved by the Local Government Board, which may refuse its approval with such modifications and subject to such conditions as it may see fit to impose. Before approval by the Local Government Board notice shall be published by the London or Edinburgh Gazette, as the case may be, and if within twenty-one days of the time of publication no interested person or authority objects to the draft or the order of approval, it shall be laid before both houses of Parliament for not less than thirty days during a session of Parliament, and if, before the expiration of thirty days, either house presents an address to the Crown against the draft or any part thereof, no further proceedings shall be taken, without prejudice, however, to the making of a new draft scheme. A town-planning scheme once adopted may be varied or revoked by the same method of procedure as that followed in its original adoption. The Local Government Board is authorized to prescribe provisions for carrying out the general objects of town-planning schemes, these objects being given in the widest terms in a schedule which is a part of the act, including the laying out and improvement of streets and roads and the closing or diversion of existing highways; the erection of buildings and other structures; the provision of open spaces, both private and public; the preservation of objects of historic interest or natural beauty; sewerage, drainage, and sewage disposal; lighting; water supply; the extinction of private rights-of-way or other easements; the disposal of land acquired by the local authorities; the removal, alteration, or demolition of any work which would obstruct the carrying out of the scheme; the making of agreements by the local authorities with owners and by owners with each other; the right of the local authorities to accept any money or property for the furtherance of the

object of any town-planning scheme, and the regulation of the administration of such money or property; the limitation of time for the operation of the scheme; the coöperation of the local authorities with the owners of land included in the scheme, and the imposition upon land whose value is increased by the operation of a town-planning scheme of the sum to be paid on account of their increase in value.

In addition to these general provisions there may be incorporated in any scheme special provisions defining the area and the responsible authority, and especially dealing with local conditions, and these special provisions may vary or supersede not only the general provisions, but even Acts of Parliament, although when any general act of Parliament is thus contravened, special opportunity is given either house by resolution to reject the scheme before it is finally approved.

A town-planning scheme may originate in any one of three different ways:

1. Land owners may formulate a scheme which the Local Government Board may authorize, or after public inquiry may compel the local authorities to adopt.
2. Any representation may be made to the Local Government Board that a scheme ought to be prepared by a local authority, and the Board may, after public inquiry, order a scheme to be so prepared.
3. A local authority may prepare a scheme, but before any public money is expended, a prima facie case must be made out and the sanction of the Local Government Board obtained.

The responsible authorities are given abundant power to enforce an adopted scheme by removing any building or work executed in contravention of the scheme, and by carrying out, at the expense of the person in default, any work which is so delayed as to prejudice the plan, and the responsible authorities may be compelled by the Local Government Board to exercise these powers.

The expenses incurred by a local authority may fall under three different heads:

1. The cost of preparing and promoting a scheme. The Act contains no provision as to this expense beyond the fact that it will be charged in the general tax of the district.

2. The cost of acquiring land for the purpose of ca
scheme. Compulsory powers of purchase may be ex
of the Local Government Board without statu
unless an impartial public inquiry shows that th

for the required purpose or cannot be acquired without undue detriment, in which case any order made by the Local Government Board must be confirmed by Parliament. The price to be paid for land compulsorily acquired is to be determined by a single Government Board arbitrator, and no additional allowance will be made by reason of the purchase being compulsory.

3. Compensation may be allowed the land-owners for injury, and this compensation is to be determined by a single Local Government Board arbitrator, but no allowance is to be made for the limitation which an adopted scheme may impose as to the number, height, or character of the buildings which may be erected, nor for any requirement of a scheme which may be in force, nor for anything done after application has been made for the right to prepare a scheme. The principle of betterment is also recognized to the extent of one-half the increase in the value of property by the scheme.

It will be seen that the powers conferred upon the Local Government Board by the Town-Planning Act are extraordinary, and perhaps unprecedented, and it is quite probable that the success or the failure of the act will depend to a large degree upon the manner in which the power is exercised.

The recent interest in questions relating to city planning can be largely credited to architects, landscape engineers, civic organizations, and those who, from motives which may be altruistic or selfish, wish to see their city made more liable and attractive. To these men and bodies must be given much of the credit due for the movements which have resulted in the establishment of dignified civic centers, the effective grouping of public buildings, and in many cases the cutting through of new thoroughfares. In few instances have engineers taken a conspicuous part in the planning or execution of such improvements other than the mere work of physical construction. If the principles enunciated in this paper are accepted as sound, it must be admitted that these spasmodic efforts, admirable as may have been their results in many cases, are not city planning. They are often spectacular, and they attract the admiring attention of the public. Real city planning is more fundamental and will render unnecessary an enormous destruction of property before real constructive work can be begun.

City planning in the sense in which the author has used it is almost wholly constructive. Some demolition of improvements there must be, but it should take place before they have assumed great value,

onal streets appears to have been recognized, however, and these were not only provided to establish direct connections with the highways outside the city limits, but they were extended toward the center, missing connections were supplied here and there until, before the public appears to have been aware of the fact, certainly before the professional city planner descended upon the city, the engineers of Philadelphia had not only gone a long way toward correcting the inherent defects of the original plan, but had provided a comprehensive and admirable scheme for future development. It is probable that much study and great expenditures will still be required to perfect this system in the older parts of the city, but there is much satisfaction to be derived from the knowledge that the mistakes of the past are not being repeated in the newer portions of the city, as is so generally the case throughout this country. Notwithstanding these facts we do not read or hear much of Philadelphia in city-planning literature and discussions, even though in this city has been held the greatest city-planning exhibition ever given in this country. This confirms the statement, already made, that the most valuable work of this kind, the work that involves a minimum of expense in destruction of improvements to attain the desired results, will attract little public attention or appreciation. The engineer who designs and builds a structure that is well adapted to its purpose and will last for generations will receive little recognition, but if such a structure fails, or if its capacity proves inadequate to increased demands, he who designs one more imposing and flamboyant to take its place will be acclaimed a genius.

The author has no desire to detract from the credit which has been given to men like Carrére, Burnham, Brunner, Olmsted, Nolen, and a number of others, for the admirable work done or proposed by them to redeem some of our cities from the commonplace. Their plans are, many of them, inspiring—some of them extravagant beyond hope of realization. Their genius can and should be availed of in the constructive work of making our cities beautiful, but the destructive features of their plans could be largely avoided if the engineers generally, as they appear to have done in Philadelphia, would bestow more careful study upon their task of preparing the original plan.

The general principles which should govern the creation of a city plan may be summed up under three headings:

Provision for future growth.

Reasonable regard for the interest of the property owner and the tax-payer, as well as the public.

which should be given the traffic streets is not only unnecessary, but the result is unpleasantly monotonous and uninteresting, with no compensating advantage. There is no reason why individual preference and ideas should not be exercised by the private developer, provided that his development does not interfere with the main arteries of traffic, and provided, also, that it is not inconsistent with good sanitary conditions. Some of the plans evolved for private development may cause a distinct shock to the engineer. This will do him no harm; in fact, he needs it occasionally for his own good.

Many developments made by individuals or corporations before the completion of the plan for the district in which they are located could be incorporated in the final plan, provided there were a disposition on the part of the developers to confer and coöperate with the city authorities before making their improvements. Inasmuch as property sold as city plots depends for its value upon a street system which will afford access, it would not appear unreasonable to prohibit by statute the sale or offering for sale of lots in unmapped sections, unless the proposed plan of streets should first have been submitted to the municipal authorities for their examination, approval, or correction in order that the proposed streets might be made to conform with the general plan of main highways proposed for the part of the city in which the property is located. A reasonable time—say six months—should be allowed for the acceptance, amendment, or rejection of the plan submitted, and if the opportunity to do so were not availed of within that time, the owner might be absolved from any obligation to further delay the improvement and sale of his property. Such a requirement would not appear to be an unreasonable restriction upon the right of the owner to use his property to the best advantage, but would be a recognition of the right of the city to control in some degree the street plan upon which that property depends for its value, while the assurance to purchasers that the street plan is definitely fixed and that the homes they build will not be destroyed by a rearrangement of the plan would add materially to the value of the property. It is quite probable that reputable real-estate developers would not oppose legislation of this character. Philadelphia does not appear to suffer from this practice as much as do other American cities, first, for the reason that its city plan seems to have been developed well in advance of improvements, and, secondly, because the erection of buildings within the lines of streets which have been laid down by competent authority is forbidden except at the risk of the

and other public buildings, commonly bought at enormous expense, could properly be reserved for future use, and it is not unlikely that both park and building sites could thus be made to pay for themselves. In the cutting through of new or the widening of existing streets in built-up sections of the city the simple right to acquire entire parcels, portions of which are needed for the new or widened street, and the sale of the surplusage after the street shall have been constructed along the new lines, would, on account of the enhanced value, enable the city to recoup a large portion of the expense, instead of adding the entire cost to the permanent debt of the city, and at the same time enriching abutting owners, first, through awards made for damage imposed, and then for the enormously increased value of the property which is left.

As already stated, there is no reason why subordinate residential streets should follow long, straight lines. This is in a measure true of main traffic thoroughfares, but in them the changes in direction should not be permitted materially to increase distance or impair directness. Topography and existing improvements may be such that expense may be saved by easy changes in direction, while at the same time the street will gain in interest and admirable sites will be afforded for important buildings, the lack of which sites is so painfully evident in a rectangular street plan.

It may be thought that the title of this paper has been forgotten, and that it has been devoted to a discussion of what the city plan is, and the effect of an intelligent plan upon the growth of the city, rather than to an attempt to point out the relation which the municipal engineer should bear to city planning. The writer has endeavored to draw a specification, crude and incomplete though it may be, of the materials to be used and the work to be done in the preparation and development of a rational city plan. Who will best measure up to the specification—the architect, the landscape architect, the civic worker, the lawyer, the business man, the real-estate developer, or the municipal engineeer? As already stated, it is no one-man job. The advice of every one of the above would be valuable and should be sought. The engineer will naturally be the first man on the ground. If he is a broad man,—a man of imagination, of human sympathy, of business ability, with a proper sense of proportion,—he will so lay the foundation of the city plan that an orderly development will follow, and a large part of the vast sums required to reconstruct the plan and make it fit changing conditions or adapt

Although there will be one center of greater importance than the others, the people should be encouraged to establish other centers for the transaction of business.

In many of our cities, particularly in Philadelphia, the street system is now so congested that there is not sufficient space, either on the surface or under ground, to care for those necessities which are so important for the comfort, convenience, and health of the people.

I agree with Mr. Lewis that it is the duty of the engineer to place upon the plan and to provide for those main avenues of transportation which are so essential for the development of every city and its adjacent suburbs, and in planning or replanning avenues of communication provision should be made and direct routes of travel laid out leading to the various centers of trade, and also to the towns in the vicinity. By planning these great avenues of communication their harmonious development will result.

The cities of Germany appear to be growing more rapidly than those in our country, yet many American towns are developing with remarkable rapidity, and unless we anticipate the needs of the future by intelligently planning for this great growth, there will be much tearing down of buildings and reconstruction of streets to furnish the necessary facilities for the carrying on of trade and the transaction of business.

It is gratifying that so many cities, both in this country and abroad, are preparing comprehensively for the future, not only in providing sufficient highways, but also open places for parks, playgrounds, and for the purpose of erecting public and semipublic buildings.

These matters must necessarily receive greater attention in the future as the people at large are realizing the necessity of providing healthy environments for the proper development and growth of cities.

B. A. HALDEMAN.—I feel that I can join with Mr. Trautwine in saying that practically every sentence of Mr. Lewis's paper provides a text for a sermon—there are so many things in it that all of us who are interested in town planning and in the proper development of a city can take home and study.

One very interesting part of it is that in regard to the comparative growth of American and German cities. It is somewhat surprising to learn that German cities have grown so much more rapidly than American cities, for the idea is prevalent that the opposite has been the case. I think a reason for this is that the methods of planning and taking care of the population of the German cities have developed them more completely. The German cities are now planning much better than formerly, and are taking advantage of their opportunities in the best possible manner. Although the growth of our American cities has been very rapid, it is probable that unless in our town planning we are able to devise ways and means for getting our people more out into the country, congestion is likely to increase more rapidly in the future than it has done in the past. Big cities, such as Boston, New York, and Philadelphia, must provide better measures for taking care of the growing population and providing the things that that population is going to need in the conduct of its daily life and business; unless they do this, they will not be doing their duty by their people.

Mr. Lewis has paid the Philadelphia engineers a very great compliment in his paper, which I trust those who have been actively engaged in the planning of Philadelphia deserve. I regret that more of the engineers engaged in that planning are not here tonight.

suburban towns and the country districts. If, in addition to the table which Mr. Lewis showed to us, we had another table comparing as nearly as may be the American cities with French cities, for instance, or Italian cities or Russian cities of the same or nearly the same population, we might perhaps reach a more definite conclusion as to the precise effect which the city planning would have on the population, because such a comparison would, to some extent, eliminate all other factors to which I have referred.

Philadelphia, with its rectangular streets and quite a number of diagonal streets, is no doubt as well situated or in as good a position for the adaptation of a comprehensive plan, such as has been spoken of by Mr. Lewis tonight, as any other city of the United States. Still the apparent introduction in some of the European plans of crooked streets in place of straight ones is not always, to my mind, the wisest plan, and I hardly believe that the introduction of crooked streets in place of straight ones would be considered the best policy in our plan, because traffic will naturally seek a straight course to reach its destination in the shortest time. Yet we all know that crooked streets sometimes cannot be avoided, as, for instance, when the grades are such as to make it advisable to deviate from the plan to avoid steep hills.

Mr. Lewis.—I would like to add a word in connection with what the last speaker has said. In considering the figures showing the increase in population of certain German cities over certain American cities, it would be well to bear in mind the fact that, during the last decade, or from 1900 to 1910, the increase in population of Germany was 16 per cent., while the increase in that of the United States was 21 per cent. There must have been, therefore, a very great drift of rural population toward the cities in Germany—a much more notable drift than was the case in this country during the last decade. A great number of the immigrants to the United States go to the cities. In New York the foreign-born population is increasing at an enormous rate. Yet, notwithstanding the movement of our own people from the country to our cities, and notwithstanding the fact that the rate of increase in the population of our entire country has been about 25 per cent. greater than the rate of increase in Germany, the German cities have still grown faster than ours.

I think it is only fair to say that in some German cities, with wide and beautiful streets lined with imposing buildings, the conditions of housing are said to be worse than those which prevail in London or in the smaller manufacturing towns of England, where the single-family house is the rule rather than the exception. The higher land values in German cities resulting from the greater cost of the improvements appears to compel a more intensive use of the residential area in order to secure a fair return on the investment.

One gentleman has confessed to a horror of increased taxation. That is inborn; we naturally dread it, and nobody likes it; but, in my opinion, we in this country do not know what taxation is in comparison with that in Europe.

Mr. Haldeman.—Although the streets and buildings of German cities are beautiful, many of the fine façades conceal conditions which are worse even than those in London. This is so true that there is probably no place in the world where such strenuous attempts have been made to improve the conditions of the people, and these attempts have produced what is called the "Zone System," under which municipal councils control the use and occupancy of land. For-

60 per cent. That law makes it impossible to put up a single tenement house, but compels the taking of a large area and the building on that large area of a suitable dwelling. The next requirement of the law is that every room in that house, every space that is not absolutely a clothes-press or similar compartment, must have a full-sized window opening to the air. That does not mean a shaft which makes an excellent draft, but it means an air-space which is, if my memory serves me correctly, 60 per cent. of the height of the highest adjoining wall. These buildings are generally put up in the form of an inclosure around a large open central space.

The next requirement is that the building must be fireproof: the doorway to the court must be constructed and located in such a way that the fire-engines can drive through—something like the entrances to our City Hall.

Mention was made of the fact that very imposing exteriors oftentimes cover wretched interiors. That is no longer true of the German cities in those portions that are growing. They do not pull down and build immediately any more than we do, but they do not allow their slums to grow. There are occasionally to be seen modern frontages, and behind them a huddle from an older period, but that is only a disappearing remnant.

Municipal work is better done in Germany than in any other country in the world; not because they are more competent than anywhere else, but over there people go into the governmental service as an absolute career. Here a boy makes up his mind what he is going to be,—a doctor or a lawyer, or what not,—while over there a boy decides for some line of public work: his whole career is shaped to that from the beginning, and in the spirit that his chosen career is his life's work. When he gets his appointment, he knows that he will go along the whole line of promotion from position to position. There is not very much pay, but he knows that if anything happens to him he will be taken care of, as will also his wife and his children, if he has any. Therefore these people do not need to get very high pay. They have no heavy expenses, and they live up to the handle of their incomes. I believe that absolute certainty of office and the fact that they follow a chosen career from the beginning make for efficiency more than any other one feature. Over there citizenship in a town has nothing to do with office holding—municipal office is not a plum awarded by a successful ward boss.

HENRY WILSON SPANGLER.

1858—1912.

(By courtesy of the Engineering News.)*

PROFESSOR H. W. SPANGLER, Whitney Professor of Dynamical Engineering at the University of Pennsylvania, died at his home in Philadelphia on March 17, 1912, of heart disease, after a serious illness of several months. The first attack of this ailment befell him in the late summer of 1909, while in the wilds of Maine, his sole companion being a guide. Upon partial recovery he resumed his duties at the University, with characteristic determination, and against the protests of his friends, until the progress of his disease compelled him, three or four months ago, to relinquish all active duties.

Henry Wilson Spangler, son of John Kerr and Margaret Ann (Wilson) Spangler, was born at Carlisle, Pa., on January 18, 1858. He was graduated with high rank at the United States Naval Academy, as Cadet Engineer, with the class of 1878. Two other members of that class have attained to prominent positions in the field of engineering education, namely, Professor Ira N. Hollis, head of the Engineering Department at Harvard University, and Professor M. E. Cooley, Dean of the Department of Engineering at the University of Michigan.

Professor Spangler was assistant engineer in the United States navy from 1878 to 1889, although for about half that period he was connected, on detached service, with the Faculty of the University of Pennsylvania, first as Assistant Professor of Mechanical Engineering from 1881 to 1884 and from 1887 to 1889, and then as full professor, holding the Whitney Professorship of Dynamical Engineering. During the Spanish-American War in 1898 he served for a brief period as chief engineer in the United States navy. With the exception of that short interval, he was in the service of the University as the head of the Mechanical and Electrical Engineering Department continuously from 1887 until his death. The high standard of excellence to

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* This memoir was prepared by Prof. Edgar Marburg, at the re
Engineering News.

which this department has attained is due largely to his remarkable talents as a teacher and his pronounced ability as an executive officer.

When he assumed his duties at the University the Department of Mechanical Engineering was housed in a single room on the third floor of College Hall, its equipment consisting only of a wooden model of a locomotive valve gear and a Crosby indicator. A small laboratory, in which the principal features were a 5 H.P. vertical boiler and a 4 by 4 inch vertical engine, connected by belt to two dynamos, was afterward installed in the basement. The establishment of a central lighting and heating plant by the University in 1891 afforded the desired opportunity of erecting, in connection therewith, a building devoted to instruction in mechanical and electrical engineering. Within two years after its construction the number of students had increased to such an extent that the capacity of this modest building became overtaxed. That condition continued until the completion, in 1906, of the present Engineering Building, affording accommodations to all the engineering departments of the University, in which the aggregate registration this year is 733.

For many years Professor Spangler also rendered highly efficient services to the University as Director of the Light, Heat, and Power Station, and was intrusted with the design of the heating, lighting, and ventilating installations for the many important buildings erected by the University.

Professor Spangler was the author of a number of standard text-books and numerous technical papers and professional reports. The text-books from his pen embrace "Valve Gears" (1890); "Notes on Thermodynamics" (1901); "Elements of Steam Engineering," in collaboration with A. M. Greene, Jr., and S. M. Marshall (1903); "Graphics" (1908); and "Applied Thermodynamics" (1910). Of these books, "Valve Gears" has passed through two editions, "Notes on Thermodynamics" through five editions, and "Elements of Steam Engineering" is in its third edition. As a writer, his chief characteristics were his painstaking efforts to present the subject in the simplest and clearest manner consistent with the intended scope of treatment, and to keep in view the practical requirements of prospective engineers, rather than theorists. As a teacher, he was lucid, stimulating, progressive, and always intensely practical. His first concern was to help the students to gain a firm grasp of the underlying principles of the subject, and then to encourage them to rely on their own resources in the application of these principles. On no

clearly, and almost intuitively, the essential elements of a seemingly difficult problem or complex situation, and he was as quick in action as in perception. Few excelled him in the clear discernment of the fallacies of an argument or in the directness of the challenge of such fallacies. Of a thoroughly progressive bent, he did not allow himself to be beguiled into strange paths by the educational fads and follies of the hour. The business of education was, to him, a serious business, with which liberties were not to be taken lightly.

Professor Spangler was married to Nannie Jane Foreman, of Carlisle, Pa., on December 1, 1881. Their union was blessed with three children, of whom one son, Henry Wilson Spangler, Jr., survives. Professor Spangler's remains are interred in Carlisle, Pa.

GEORGE WALLACE MELVILLE.

JOHN C. TRAUTWINE, JR.

Presented April 6, 1912.

George Wallace Melville was born in New York city January 10, 1841, of Scottish ancestors, whose records abound in evidence of that uncompromising decision of character which so strongly marked him.

After early education in the public schools of Brooklyn and a scientific course in the Brooklyn Polytechnic Institute, he was apprenticed to the proprietor of a machine-shop in East Brooklyn.

Upon the outbreak of the civil war, in 1861, he entered the United States navy as third assistant engineer of a steam frigate, and he remained in the service of the Navy Department until his retirement in 1903, and in intimate relations with it up to the time of his death, on March 17, 1912.

During the civil war he was active in many important engagements, notably in the ramming of the Confederate cruiser "Florida" by the "Wachusett," in Bahia harbor, Brazil, in October, 1864. Melville urged ramming, but the officers of the "Wachusett" hesitated, fearing rupture of her boilers; whereupon Melville, with one fireman, who refused to leave him, operated the boilers and engine of the "Wachusett," and the "Florida" was successfully rammed.

About 1865 Melville took part in surveys on the American Isthmus, looking to the determination of the feasibility of an interoceanic ship-canal.

He was several times stationed at the Philadelphia Navy Yard as assistant to the Chief Engineer.

In 1887, while acting as inspector at Cramps' ship-yard in Philadelphia, Melville was appointed, by President Cleveland, Chief of the Bureau of Steam Engineering, and ex officio Engineer in Chief of the United States navy, and he served in this capacity four terms of four years each, until his retirement, in 1903, serving u' administrations of Presidents Cleveland, Harrison, McK Roosevelt. Under the Personnel Law of March 4, 1 Rear-Admiral.

To the general public Melville is perhaps best known by his three arctic expeditions: First, in 1873, as engineer officer of the "Tigress," which rescued Captain Hall's "Polaris" party off the coast of Labrador; second, and most notably, in 1879–82, as engineer officer of the "Jeannette," under command of the ill-fated George W. De Long, whose remains were afterward found by Melville, after long search attended by incredible hardships; and third, in 1883, as Chief Engineer of the flagship "Thetis," of the squadron under Admiral (then Captain) Winfield S. Schley, which found and rescued Greely and the survivors of his party at Cape Sabine, North Greenland. For his participation in this exploit Melville received, from Congress, a gold medal and an advance of fifteen numbers in rank. The two expeditions last named are described in his book entitled "In the Lena Delta," Boston, 1885.

Among Melville's numerous inventions was a hinged periscope for submarines, enabling them to operate in shallower waters than were practicable with the fixed type. In coöperation with Mr. Henry G. Bryant, recently President of the Geographical Society of Philadelphia, he devised a sealed cask, to be used by navigators in arctic seas, for the purpose of showing, by their drift, the directions and velocities of ocean currents.

His best-known invention, however, is the speed-reduction gear for turbine steamers, recently elaborated in conjunction with his late partner, Mr. John H. Macalpine, and constructed and successfully tested by Mr. George Westinghouse, at the works of the Westinghouse Machine Company, East Pittsburgh. At a meeting of this Club, held January 6th of the current year, Rear-Admiral John R. Edwards read, for Admiral Melville, who was present, a paper explaining the design, construction, and application of this speed-reducer.

One of Melville's most noteworthy contributions to the literature of applied science is recorded in the "Report of the U. S. Naval 'Liquid Fuel' Board," showing the relative efficiencies of coal and of liquid fuel, as determined by a series of tests made under his direction and prosecuted uninterruptedly for twenty-eight months. The report was published at the Government Printing Office, Washington, in 1904.

In a paper printed in the Annals of the American Academy of Political and Social Science, July, 1905, Admiral Melville expressed the view that "our voluntary assumption of responsibilities beyond our natural boundaries is, from a naval viewpoint, a serious weakness," and that the building of the Isthmian Canal, "while in a purely naval

and in the warm regard in which they held him. Although his life was devoted to the service of his country, he took no interest in that scramble for place and power which we miscall "politics," and it was his boast that he had never cast a vote.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, March 16, 1912.—The meeting was called to order by Vice-president Hewitt at 8.20 p. m., with 99 members and visitors in attendance. The minutes of the Business Meeting of March 2d were approved as printed in abstract. Mr. H. H. Quimby, Chairman of the Committee on Public Relations, presented the following resolution, which was unanimously adopted:

"*Resolved,* That it is the sense of this Club that the patent laws of the United States are in need of revision, in order to safeguard more completely and equitably the interests of both inventors and the public, and that to this end the President of the United States should be authorized by Congress to appoint a commission of competent persons to make a study of the subject, and suggest such legislation as may appear to be wise and efficacious."

It was further moved and carried that the Secretary be instructed to transmit a copy of this resolution to Congress.

Mr. B. A. Haldeman, chairman of a special committee appointed to represent the Club at a conference in the Mayor's office on "The Promotion of the Systematic Planting and Care of Shade Trees in the City," moved the adoption of the following resolution, which also was carried:

"*Resolved,* That the Engineers' Club of Philadelphia recommend that the sum of $50,000 be appropriated by Councils to the Commissioners of Fairmount Park, acting as the Shade Tree Commission of this city, to be used in encouraging and assisting the planting of shade trees in the streets of the city, and in maintaining such trees as now exist or may hereafter be planted."

Dr. John A. Brashear, of Pittsburgh, Pa., presented the paper of the evening, entitled "Stellar Evolution," which was followed by short addresses by Professor Charles L. Doolittle and Professor M. B. Snyder. On motion of Mr. John C. Trautwine, Jr., the thanks of the Club were extended to Dr. Brashear for his extremely interesting and instructive paper.

Business Meeting, April 6, 1912.—The meeting was called to order by Vice-president Plack at 8.30 p. m., with 82 members and visitors in attendance. The minutes of the Business Meeting of March 16th were approved as printed in abstract.

Dr. Marburg presented a memorial of Henry Wilson Sr
of the Club, prepared by Dr. Marburg and Professor
presented a memorial of George W. Melville, pres
wine, Jr.

Following a report of the Tellers, the follo

bership: Active, Morris L. Cooke, William H. Hultgren and Alexander T. Lewis; Junior, Carl D. Buchholz and Frederick W. Reuter.

Mr. George W. Tillson presented the paper of the evening, entitled, "Recent Improvements in Street Pavements," which was discussed by Messrs. Wm. Easby, Jr., S. M. Swaab, J. E. Fulweiler, and others. On motion of Mr. Easby the thanks of the Club were extended to Mr. Tillson.

Regular Meeting, April 20th.—The meeting was called to order by President Hess at 8.30 p. m., with 96 members and visitors in attendance. The minutes of the Business Meeting of April 6th were approved as printed in abstract. Several amendments to the By-laws were presented and read in abstract, and announcement was made that these would come up for discussion at the Regular Meeting of the Club on May 18th.

Mr. H. E. Longwell, Consulting Engineer of the Westinghouse Machine Co., presented the paper of the evening, entitled, "The Gas Producer," which was discussed by Messrs. John C. Trautwine, Jr., Henry Hess, E. M. Nichols, Walter L. Webb, and others. On motion of Mr. E. S. Hutchinson a vote of thanks was extended to Mr. Longwell.

Regular Meeting, May 4th.—The meeting was called to order by President Hess at 8.30 p. m., with 90 members and visitors in attendance. The minutes of the Business Meeting of May 4th were approved as printed in abstract.

Following a report of the Tellers, the following were declared elected to membership: Associate, Clark Judson Hollister; Junior, H. Lawrence Hess and Charles Henry Schaefer.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City, presented the paper of the evening, entitled, "The Engineer in His Relation to the City Plan," which was discussed by Messrs. J. C. Trautwine, Jr., G. S. Webster, B. A. Haldeman, Henry Hess, Robert Schmitz, and E. S. Hutchinson.

On motion of Mr. Webster a vote of thanks was extended to Mr. Lewis.

Business Meeting, May 18th.—The meeting was called to order by President Hess at 8.40 p. m., with 55 members and visitors in attendance. The minutes of the Business Meeting of May 4th were approved as printed in abstract.

The amendments to the By-Laws were presented, and, after discussion, were amended and ordered printed and sent to the members for ballot.

Mr. John C. Trautwine, Jr., presented the papers of the evening, entitled, "The Significance of 'The Middle Third'" and "The Behavior of Cast Zinc Under Compression," which were discussed by Messrs. J. E. Gibson, W. P. Dallet, H. H. Quimby, W. L. Webb, N. W. Akimoff, and Carl Hering. Mr. Trautwine followed these papers with a short talk on his recent visit to Panama.

Business Meeting, June 1, 1912.—The meeting was called to order by President Hess at 8.40 p. m., with 81 members and visitors in attendance.

Following the report of the Tellers, the President declared that the amendments submitted to them for vote were carried and would be incorporated in the By-Laws.

The following gentlemen were declared elected to membership in the Club: Active, William H. Connell, James Benney McCord, and Robert Parker Raynsford; Junior, Theodore W. Pinard, George Franklin Pond, and Alexander Wilson, 3d.

The Board of Directors submitted the following names to constitute a Committee on Nominations for the coming year: Wm. Easby, Jr., Chairman; H. H. Quimby, H. E. Ehlers, W. P. Dallett, E. P. Haines, John C. Trautwine, Jr., and James M. Dodge.

Mr. S. M. Swaab, member, presented the paper of the evening, entitled, "The Queen Lane Filtration Plant," which was discussed by Messrs. N. W. Akimoff, G. S. Cheyney, J. C. Trautwine, Jr., J. A. Vogleson, and Cav. Luigi Luiggi.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

REGULAR MEETING, April 18, 1912.—Present: President Hess, Vice-President Plack, Directors Halstead, Worley, Cooke, Gilpin, Vogleson, Berry, Haldeman, Swaab, the Secretary, and the Treasurer.

The Secretary presented a statement of the financial condition of the Club, which showed a net gain in the income and expense account for the first three months of 1912 of $161.82.

The Treasurer presented a statement of the delinquent accounts, which showed that about one-fourth of the total amount owing on these accounts had been collected as a result of the notice recently put into effect.

Mr. Clayton W. Pike was reinstated as Active Member of the Club as of January 1, 1911.

The resignations of Messrs. C. E. Carpenter and R. R. M. Carpenter were read and accepted. The resignation of Mr. W. H. Johnson, Jr., was accepted.

Mr. Charles F. Mebus was appointed official delegate to attend the meeting of the electors of State College for the election of Trustees.

On recommendation of the various committees, Mr. George F. Pawling and Henry A. Moore were appointed Associate Members of the House Committee, Mr. Frank T. Gucker and Mr. George W. Hyde of the Publicity Committee, and Mr. James Mapes Dodge of the Finance Committee.

The old projecting lantern was, on request of Professor H. E. Ehlers, donated to the Whitney Engineering Society of the University of Pennsylvania.

The sum of $319 was appropriated to the House Committee for the installation of a water-pressure pump to supply the third and fourth floor bath-rooms, provided such apparatus met all the hygienic conditions demanded by the Committee. Mr. J. A. Vogleson was appointed a special member of the House Committee for the consideration of this question.

It was moved and carried that a special Committee, to consist of the President, the Secretary, and the Chairmen of the House, Finance, and Library Committees be authorized to select and appoint a business manager for the Club, at a salary not to exceed $1800 for the first year, plus such bonus as appeared best to the Committee, but not to exceed 20 per cent. of the net increase in income to the Club.

The meeting adjourned upon motion to continue at 6.30 P. M. on Saturday, April 20th.

ADJOURNED MEETING, April 20, 1912.—Present: President Hess, Vice-Presidents Plack and Mebus, Directors Haldeman, Swaab, Halstead, Vogleson, Kerrick, Gilpin, Worley, the Secretary, and the Treasurer.

The report of the Committee on Amendments to the By-Laws was read, dis-

cussed, and finally adopted, subject to a few minor amendments. It was further ordered that these amendments be presented to the Club at its regular meeting on April 20th.

Regular Meeting, May 16, 1912.—Present: President Hess, Vice-President Mebus, Directors Worley, Develin, Gilpin, Vogleson, Haldeman, Yarnall, the Secretary, and the Treasurer.

A letter from Mr. H. E. Ehlers, thanking us for the lantern, was read.

Reports of the Finance Committee, Membership Committee, and Library Committee were read and approved.

The Chairman of the Library Committee notified the Board that he had appointed Messrs. F. N. Morton and Manton E. Hibbs as additional members of this Committee. The Committee was authorized to expend a sum not exceeding $25 for the use of the library. The House Committee's report was read and approved. Mr. Worley tendered his resignation as Chairman of the House Committee. It was accepted with regret. A vote of thanks was tendered to Mr. Worley for his able services.

The Advertising Committee presented a schedule of rates which was adopted.

The manager's report was read and approved.

The amendments to the By-Laws were discussed.

Adjourned Meeting, June 13, 1912.—Present: President Hess, Vice-Presidents Plack and Mebus, Directors Halstead, Kerrick, Worley, Cooke, Develin, Gilpin, Vogleson, Berry, Haldeman, Swaab, Yarnall, the Secretary and the Treasurer.

The Secretary presented a statement of the financial condition of the Club, which showed a gain in the income and expense account for the first five months of 1912 of $27.14.

The Committees on Finance, Membership, Publication, Library, House, and Publicity did not present formal reports.

The Meetings Committee presented a formal report, stating the principal papers presented during the past season, and a list of papers they hoped to secure for the coming winter.

It was ordered that a condensed copy of the minutes of each Board meeting be sent to each member of the Board.

The Committee on Nominations, appointed by Mr. Hess, as announced in the last notice, consisting of Wm. Easby, Jr., Chairman; H. H. Quimby, H. E. Ehlers, W. P. Dallett, E. P. Haines, J. C. Trautwine, Jr., and James M. Dodge, was ratified.

The question of smoking during Club Meetings was considered, and it was moved and carried that this question be again referred to the Club, with the recommendation of the Board that this smoking be abolished.

A letter from the National Society for the Promotion of Industrial Education was read and referred to the Committee on Public Relations for report.

The report of the manager was presented and approved.

It was moved and carried that a section be added to the rules [illegible] Directors providing for a letter ballot, and that a corrected [illegible] sent to each member of the Board.

The election and transfer of members, which was to have been brought before this meeting, was postponed until the following meeting, owing to the absence of a majority of the Committee on Membership.

On motion of Captain Cooke it was moved and carried that a period of at least ten days elapse after the printing of the records of candidates and action upon them by the Membership Committee.

Following a general discussion of house affairs, the meeting adjourned at 9.45 P. M., to continue on call of the chair.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

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PAPER NO. 1112.

SMOKELESS POWDERS AND EXPLOSIVES FOR MILITARY USE.

ODUS C. HORNEY.
(Visitor.)
Lt. Col., Ord. Dep't, U. S. A.

Presented before the Club, March 2, 1912.

IT has been stated that the development of civilization has kept even pace with the increase and growth of the means of destruction at the disposal of mankind. It was by his superior means of destruction that man conquered the wild beasts of the forest, and it is by the same means that the more highly civilized races have succeeded in imposing their civilization on barbarians and savages.

The stronger the means of offense and defense possessed by any society, the less is the danger of interruption in its growth and progress. This has been true in the past, and is equally true to-day. Only a strong, fearless people, safe in the knowledge that their very strength insures them against attack, can hope to grow and prosper. We may theorize and moralize all we please, but the cold fact remains, that might makes right in the world politics of to-day.

Powders and explosives, the most powerful agents of destruction known to man, have always played an important part in the progres of civilization, and they are, therefore, of great interest to us all

But our interest in explosives is not confined to their
While they were first developed for use in war, they h

one of the absolutely necessary agents in the prosecution of large engineering works.

But for blasting powder, the drilling of tunnels and subways, the quarrying of stone and the mining of ores would be almost incredibly slow and the digging of the Panama Canal or the prosecution of similar enterprises would be all but impossible.

Before describing the more modern explosives, it will be worth while to refer briefly to the old-fashioned gunpowder.

It is now generally believed by those who have studied the subject, that gunpowder was not known before the thirteenth century; although it has been claimed by some that the Chinese and Hindus were familiar with it from early ages. It is probable that gunpowder was developed from Greek fire, and it is practically certain that Berthold Schwartz, of Freiburg, was the first to suggest its use as a propulsive agent in guns. This was about 1313.

This suggestion of Schwartz revolutionized the methods of warfare; but, strange to say, no radical improvement in the quality of powder was made until within the last century.

The first scientific attempt to control the rate of burning of gunpowder was made a little over fifty years ago, by General Rodman, an Ordnance Officer of the United States army. He suggested that since the burning of powder was a surface action, the rate of burning, and therefore the pressure developed in the gun could be controlled by varying the size of the grains. He also advocated the use of perforated grains, but while his suggestions that the size of grains be varied to suit different guns was promptly adopted, perforated grains did not come into use until a number of years afterward.

The use of perforated hexagonal grains, and, later, the use of underburned charcoal in the so-called brown powders, marked the limit of improvement in old-fashioned gunpowder for military use, and in recent years smokeless powder has entirely superseded it as a propelling agent in guns.

It is interesting to note, however, that while smokeless powder did not begin to displace black and brown powders until the beginning of the last decade of the nineteenth century, gun-cotton, which is the base of all modern military powders, was discovered by Dr. Schönbein in 1846. A small quantity of Dr. Schönbein's explosive cotton, as it was then called, was brought to this country in the same year by Mr. William H. Robertson, United States Consul at Bremen, together with Schönbein's formula and specifications for its manufacture.

He fired two rounds from the cannon pendulum, one using a one pound charge, and one using a two pound charge. In commenting on the results, he says: "There was no smoke from the discharge and only a slight acid odor. * * * To those near the gun the report seemed to be sharp and loud; but persons at a distance of 200 or 300 yards represented the sound as being very slight; far less than that made by the charge of four pounds of gunpowder, with which the gun is often fired, and even less than that of a 6-pdr. gun in salute."

In comparing the results with those obtained with gunpowder, he says: "It appears, therefore, that the projectile effect of one pound of gun-cotton in a cannon is equal to that of 2½ pounds of cannon powder, and the effect of two pounds of the former equal to that of four pounds of the latter, being nearly the same proportions as in the musket. From comparing the recoil of the gun pendulum with the vibration of the ballistic pendulum, I conjectured that the explosive or bursting effect of the gun-cotton is much greater in proportion to its propelling force than that of gunpowder."

Later on he made a number of other tests with the musket, to determine whether gun-cotton could be safely used as a substitute for gunpowder, but found that, "In consequence of the quickness and intensity of action of the gun-cotton when ignited, it cannot be used with safety in our present firearms."

While the fact that the explosion of gun-cotton did not cause any smoke was noticed by Captain Mordecai, it does not seem to have impressed him as being a matter of importance, and he does not refer to it in summing up his conclusions at the end of his report.

Nothing further seems to have been done by any one, looking to the use of gun-cotton as a substitute for gunpowder as a propellent, until Captain Edward Schultze of Berlin published a pamphlet in 1865, relating to a nitrocellulose powder which he had invented.

This seems all the more remarkable since Dr. Hartig in 1847 published a pamphlet in which he stated that gun-cotton could be dissolved in acetic ether, and that if the residue left, after the ether had evaporated, were placed in dilute alcohol and afterward dried, it would have the same properties as the original fiber, except that the explosive force would be reduced.

Captain Schultze's powder was made of thin discs of wood, which were bleached, boiled with soda, and finally nitrated in pretty much the same way that cotton is nitrated now-a-days. Later on he used

nitroglycerin, and was not improperly designated as a nitroglycerin powder; but the present cordite, usually designated as cordite M. D., contains only 30 per cent. of nitroglycerin; 65 per cent. being nitrocellulose and 5 per cent. mineral jelly. Nitrocellulose is, therefore, the principal ingredient of all military powders, and its manufacture is for that reason of particular interest.

Cellulose is not the name of a clearly defined substance, but is a generic term applied to a class of substances which have many chemical and physical characteristics in common. The composition of the celluloses corresponds to the empirical formula $C_6H_{10}O_5$ and early investigators of the cellulose nitrates assumed that that was the real formula. They referred to the highest degree of nitration as trinitrocellulose, and to the next lower degree as dinitrocellulose; but it is now recognized that the real formula is some multiple of the empirical formula.

While the exact formula has not been determined, all known cellulose nitrates can be accounted for satisfactorily by assuming that it is four times the empirical formula. It has not been found possible to introduce more than twelve NO_2 groups into the cellulose molecule, and if this be assumed as $C_{24}H_{40}O_{20}$, the nitrogen would be 14.16 per cent.; but the highest stable nitrate contains only about 13.5 per cent. of nitrogen. In practise it is found that a mixture of different degrees of nitration is obtained, the process of nitration being, apparently, a progressive one.

The cellulose nitrates for military use may be divided, roughly, into three classes: (a) Those of the highest degree of nitration, and which are only partially soluble in ether and alcohol. These are usually referred to as high-grade gun-cotton, or simply as gun-cotton. Military gun-cotton usually contains about 13.3 per cent. of nitrogen. (b) Those containing from about 12.4 to 12.8 per cent. of nitrogen, and which are practically entirely soluble in ether and alcohol. They are usually referred to as pyrocellulose, pyrocollodion, or simply pyro. (c) The lower nitrates which are soluble in ether and alcohol are generally referred to as collodion cottons.

The first two classes are the ones most extensively used, and the only ones used for military purposes in this country; although collodion cottons are mixed with cottons of higher nitration in the manufacture of foreign powders. Material of the first class, or gun-cotton, is used as a bursting charge for mines, torpedoes and projectiles; and pyrocellulose, the second class, is the base of our smokeless powders.

Whichever process is used, the degree of nitration, generally expressed by stating the percentage of nitrogen contained in the nitrocellulose, is controlled by varying the strength and composition of the acid used, the temperature at which the nitration is conducted, and the length of time the cotton is allowed to remain in the acid.

After the nitration of gun-cotton is completed, it is necessary to subject it to very careful and thorough purification, as its keeping qualities are dependent upon the thoroughness with which this purification is carried out. The specifications for powder intended for the United States army or navy require that the nitrocellulose shall be first given five boilings with a change of water after each boiling, the total time of boiling being forty hours.

This is generally referred to as the "preliminary purification." Every step in this and all succeeding operations is closely watched, and the utmost cleanliness and strictest compliance with every detail of the specifications is insisted upon.

Following the preliminary purification the nitrocellulose is finely pulped. The introduction of the practice of pulping gun-cotton during the purification process was one of the most important steps ever taken in the improvement of its manufacture. As cotton fibers are tubular in form, it has been found practically impossible to remove all traces of acid and of unstable products of nitration, until the fibers have been cut up into very short lengths.

After being reduced to a pulp the gun-cotton is given six more boilings, with a change of water after each, followed by ten cold water washings. This is usually referred to as the final purification. It is then subjected to rigid stability tests before acceptance.

Before the purified pyrocellulose is converted into powder it must be freed from water. The moisture is first reduced to about 30 per cent. by means of centrifugal wringers, after which the partially dried material is placed in the cylinder of a hydraulic press and compressed into a compact mass. Alcohol is then forced through the cotton by means of compressed air, thus displacing the water, and leaving the nitrocellulose saturated with alcohol. After the excess of alcohol has been squeezed out of it, the nitrocellulose leaves the dehydrating press in the form of a cylindrical block.

It is next transferred to mixing or kneading machines, where the required amount of ether is added. The best proportions of ether and alcohol have been found to be two parts of ether and one part of alcohol by volume. The amount of this mixed solvent varies in

erte," there have been heated discussions as to the relative merits of nitrocellulose and nitroglycerin powders; one expatriated American going so far as to write a letter to the President of the United States, in which he severely criticized the multiperforated powder used in this country, and charged that the bursting of guns in our service was due to its use. The writer of this letter, Sir Hiram Maxim, enclosed with it an article from "Engineering" of which he is, presumably, the author. This article, appearing, as it did, in a widely known magazine, attracted considerable attention, and if the criticisms of our powder contained in it were based on facts they would be serious indeed.

Whether a smokeless powder is satisfactory or not depends principally upon two things—its chemical composition and its form of grain. Its stability and reliability under the various conditions of storage and use depend upon its chemical composition, the purity of its ingredients and the care with which it is manufactured. Its behavior in the gun, or its shooting qualities, are further affected by its form of grain. The multiperforated form of grain which is used by the United States, and which has been so sharply attacked by Sir Hiram Maxim, was adopted for good and sufficient reasons which will now be explained.

The form of this grain is that of a cylinder having a length about two and a half times its diameter, and pierced with seven holes running through it lengthwise.

The burning of powder being a surface action, it is evident that the rate at which gas is given off is proportional to the burning surface. If a powder is composed of solid grains of any form, these grains will grow smaller as they burn, and the gas will be given off more and more slowly; but with the multiperforated form of grain the area of the seven perforations increases faster than the area of the outside of the grain decreases, so that as a whole the surface increases as the grain burns.

When a charge of smokeless powder is fired in a gun, the pressure behind the projectile increases as the powder burns, and soon becomes great enough to cause the projectile to start forward in the bore. This movement of the projectile increases the volume to be filled with gas, and as the projectile gains in velocity, this volume grows [illegible] at an increasing rate. In order to avoid a drop in pressure t[illegible] at which the powder gives off gas must also increase in the sam[illegible] The multiperforated form of grain comes nearer than any ot[illegible]

doubts in the minds of many who have read them, as to whether the powders used by the U. S. Army and Navy are what they should be.

The American public naturally wants to know that the powder that is put into the hands of its army and issued to its battleships is, at least, as good as any in use by foreign powers; and that the safety of ships and men is not menaced by its unreliability. I feel, therefore, that those who know the facts should not hesitate to speak of them whenever an opportunity occurs.

The articles in question make four general assertions: 1st. That nitrocellulose powder is inherently less stable than nitroglycerin powder. 2d. That both kinds are more liable to deteriorate when stored in air-tight containers than when exposed to the air. 3d. That the presence of mineral jelly in cordite protects it against dampness, and that air-tight storage-cases are, therefore, not necessary, as with nitrocellulose powders. 4th. That the navies which use nitroglycerin powder have had fewer accidents from defective powder than those who use pure nitrocellulose powder.

Strange to say, very little stress is laid upon the one and only important advantage which nitroglycerin powder possesses over nitrocellulose powder; which is this: Nitrocellulose powder is deficient in oxygen, while nitroglycerin powder contains an excess of oxygen. The combustion of the latter is, therefore, perfect and, pound for pound, it is a more powerful powder. A smaller charge of nitroglycerin powder is required to obtain any given velocity than would be required with nitrocellulose powder. The chamber of the gun may, therefore, be made smaller. This means a smaller and lighter gun, and a saving in weight is no small matter on board ship. When you have said this in favor of nitroglycerin powder, however, you have stated almost its only advantage over nitrocellulose powder.

Its temperature of explosion is much higher and it, therefore, causes much more rapid erosion of the gun. As an illustration of the difference between the two powders in this respect, it may be said that actual tests have shown that the accuracy of the caliber .30 service rifle remains as good after 15,000 rounds fired with nitrocellulose powder as after only 3,000 rounds with nitroglycerin powder.

Considering the first of the four general assertions above mentioned, it may be stated with confidence that the weight of evidence is overwhelmingly against the claim that nitrocellulose powder is inherently less stable than nitroglycerin powder. Let me quote

from an article which appeared in "Engineering" magazine itself some years ago:

"The most important considerations in determining the best composition of powders are (a) keeping qualities and safety under normal climatic conditions; (b) capability of highest possible ballistics; (c) regularity in results not to be seriously affected by change of climate, or not to cause excessive erosion. *All* these qualities are secured by the use of the properly manufactured nitrocellulose powder, and *none* can be said to be met by any powder containing nitroglycerin."

The weight of evidence is decidedly in favor of the opinion that both nitrocellulose and nitroglycerin powders keep better in air-tight cases than in cases which are not air-tight; and the claim that because it is made more or less waterproof by the mineral jelly which it contains, cordite may be stored in open cases, loses its force. As a matter of fact, British naval regulations require that cordite charges shall be kept in sealed cases, and lay great stress on this requirement.

The statement that the navies using nitrocellulose powders have suffered more from accidents due to defective powder than those which use nitroglycerin powder, is not supported by facts. Four vessels have been destroyed by explosions believed to be due to bad powder. The Aquidaban, the Jena, the Mikasa, and the Liberte. The first and third carried cordite, and the second and fourth nitrocellulose powder. Other accidents in the magazines of the British vessels Revenge and Fox, due to decomposing cordite, have been commented upon by "Engineering" itself. Although exact information is difficult to obtain, it is believed that accidents due to bad nitroglycerin powders have been more numerous than those due to bad nitrocellulose powders.

It is not claimed by any one, so far as I am aware, that nitrocellulose powder remains perfectly stable under all conditions of storage for an indefinite length of time. Under the action of heat and moisture both kinds of powder will deteriorate; but it may be added that while nitrocellulose powder will in general decompose slowly and finally lose its explosive properties, nitroglycerin powder is more apt to explode. Under extremes of heat and cold nitroglycerin powder is liable to sweat; that is, nitroglycerin will exude and collect on the surface. When this occurs, the powder is very dangerous to handle. Finally, it may be added, that while our older nitrocellulose powders have shown very satisfactory stability under

ordinary conditions of storage, our newer powders, that is to say, those which have been manufactured since 1908, are even more stable, a stabilizer having been used since that date.

It may, therefore, be confidently asserted that better powder is not made anywhere in the world than in the United States for the army and navy; and nowhere is greater care taken to secure a uniformly high grade product.

It is not to be supposed, however, that our search for improvements has ceased. Like the powder makers of other countries, we are now seeking a flashless powder.

The flash from a gun firing smokeless powder is intensely bright and this flash is of great assistance in locating the position of an enemy's guns, especially during night firing. A demand has, therefore, grown up for a flashless or flameless powder.

The intensity of the flame from smokeless powder is due principally to its high temperature of explosion, which causes the particles of residue to become incandescent. The addition of some ingredient to cool the flame is, therefore, required if a flameless powder is to be produced. Sodium bicarbonate was the first substance suggested. It cools the flame by losing its water of crystallization and carbon dioxide. Oils, soaps, etc., have also been proposed.

No flashless powder has been adopted in any service so far as I know, although a number have been offered for test; but I believe it is only a question of time, and a short time at that, before its use will be general.

With the silencer already an accomplished fact, success in our search for a flashless powder will enable artillery to bombard an enemy without being seen, without smoke, flame or noise.

Turning now from the consideration of powders to high explosives, it will be well to explain some of the more important requirements that a satisfactory military explosive must fulfil. As stated before, the distinction between a powder and a high explosive is based upon the rate of explosion. Powders burn, and the rate of burning can be controlled; but the decomposition of a high explosive seems to take place throughout its entire mass almost at the same time.

Materials which explode with great violence are said to "detonate" or to give a high order of explosion; while those, like gunpowder or smokeless powder, are said to give a low order of explosion. Some explosives like the fulminates, or nitroglycerin, always detonate; on the other hand, smokeless powder always gives an explosion of a low

not be hygroscopic or else its explosion shall not be affected by the presence of moisture. Wet gun-cotton, besides being one of the safest of all high explosives, is particularly well suited for use in damp situations. Being already wet, a leak in the walls of a mine would not be of serious moment. The greatest drawback to the use of wet gun-cotton is the fact that it requires a priming charge of dry gun-cotton to properly detonate it, and dry gun-cotton is one of the most dangerous explosives we have to handle. In spite of this drawback, however, gun-cotton has been, and still is very largely used for mines and torpedoes, although other explosives are pressing for recognition. One of the most promising of these is trinitrotoluol, which is absolutely non-hygroscopic, is safe to handle, and is easy to detonate. The supply of raw material for its manufacture, toluol, is practically unlimited; and like the other nitro-compounds of this class, it remains stable for an indefinite length of time.

When we come to the selection of an explosive for projectiles, the greatest difficulty is encountered. This very difficulty has seemed to act, however, as a spur to inventors, and the number of explosives that have been offered for test in the military service is almost countless. Potassium chlorate, because of the large amount of oxygen which it contains and the readiness with which this oxygen is given off, seems to have a particular fascination for inventors, and combinations of potassium chlorate with some carbonaceous matter are patented with tiresome regularity. A great many of these potassium chlorate mixtures have been tested, but few of them have given promising results. The chlorate is liable to be dissolved out, if the explosive becomes damp, and may recrystallize and render the explosive very sensitive to shock.

Among the most important of the explosives which have been tested in this country at various times for use in filling projectiles may be mentioned nitroglycerin, blasting gelatin, picric acid, emmensite, joveite, maximite, trinitrotoluol, trinitrobenzol and wet gun-cotton.

The extreme sensitiveness of nitroglycerin renders its use absolutely impracticable, and blasting gelatin is also exceedingly dangerous, due to the large percentage of nitroglycerin which it contains.

In recent years picric acid has been used in some form or other, or in combination with some other material by practically all large military powers as a bursting charge for projectiles. It is interesting to note in this connection that the explosive properties of picric acid

ary armor overmatches a heavy projectile if the striking angle be very oblique. It is for this reason that some artillerists favor the use of comparatively weak projectiles with large cavities holding heavy charges of high explosives, and fitted with quick acting fuses. which cause the projectiles to explode upon impact.

If a projectile is made strong enough to penetrate heavy armor, its walls must be thick, and the bursting charge comparatively small. If such a projectile, fitted with a delayed action fuse, strike an armor plate at a very oblique angle, it will glance from the plate, and. because of the delayed action of the fuse, the explosion of the charge will take place too late to reinforce the blow of the projectile. The effect on the armor will, therefore, be no greater than it would have been if a solid shot had been used.

The effects produced by the two methods of attack: First, the projectile carrying a charge of blasting gelatin, the most powerful of explosives. The inventor, who proposed the use of this very sensitive explosive, devised a special form of shell in which the charge of gelatin was divided into a number of sections by diaphragms in order to reduce the shock on the explosive. His shell was longer than an ordinary armor piercing shell and carried a large charge of explosive. He made no effort to secure penetration, but hoped to be able to smash the armor plate and stave in the side of the vessel by the force of the explosion.

The first round was fired from a 12-inch gun at an angle of impact of 45° C. The plate was carried some distance along the side of the butt, but was unbroken. The wooden support was repaired and the plate set up in its original position.

A second projectile filled with blasting gelatin was then suspended against the plate and exploded electrically, without material injury to the plate.

It will be interesting to compare these results with those obtained by firing a service 12-inch shell against an armor plate, and causing it to explode in rear of the plate.

Later on, a third projectile charged with over 175 pounds of blasting gelatin was fired against a target representing a section of a battleship. The impact was normal to the armor plate. A slight depression was made in the face of the plate, and the entire structure was moved to the rear about four inches; otherwise the target was not damaged.

PAPER NO. 1113.

THE QUEEN LANE FILTRATION PLANT.

S. M. SWAAB.
(Active Member.)

Read June 1, 1912.

INTRODUCTION.

THE subject of the water supply of the city of Philadelphia has received considerable attention from The Engineers' Club, and in our Proceedings are several papers descriptive of the works. It is not my intention, other than in a general way, to speak of the Water Supply *per se;* but rather to describe in detail, historically and otherwise, the construction of the last unit of the Filtration System, begun in the year 1901, and prosecuted during about ten years of the period intervening between that date and the present.

This paper contains a historical sketch of the Queen Lane Filter Project, as well as a description of the construction and method of operation of the Queen Lane Filter Plant of the Philadelphia Water Supply, and also a brief outline of the process of the purification of water by slow sand filtration and of the evolution of that process.

HISTORICAL.

Benjamin Franklin it was, I believe, who first publicly called the attention of the citizens of Philadelphia to the very important subject of obtaining water for the city from some other source than the wells then universally used, urging that the affiictions from the ravages of contagious disease rendered it necessary that a more copious supply of water should be procured to insure the health, comfort and preservation of the citizens.

This was about the year 1793 or 1794, just after the city had been visited by the yellow fever; and in Franklin's will, dated June 23d, 1789, is the following clause: "And having considered that the covering of the ground plot of the city with buildings and pavements, which carry off most of the rain, and prevent its soaking into the earth, and

While marked reduction in typhoid fever rates follow in all cases where that disease has been water borne, there also occurs a reduction in the total mortality rate of cities which improve their water supplies which cannot be accounted by the reduction in typhoid. I am under the impression that this fact was first pointed out by Professor Sedgwick. It was called to my attention by Mr. Nicholas Hill, of New York, who suggested that the mortality statistics of Philadelphia should be closely studied in this respect, since the concurrent reduction was, in all probability, not due to coincidence of other beneficial factors. It can be said at this time that the general reduction has every indication for prevailing in Philadelphia, in this, the first year of filtration of the entire supply. Should the indicated rates obtain for the full year, there will be about 2000 less deaths in Philadelphia in 1912 than occurred in 1911. More complete analysis than has been possible up to this time may show that in ascribing the benefits due to the improved water supply we should not overlook advancements in the public health, other than reductions in typhoid fever.

and, for the maximum unit pressure, p_a, at a:

$$p_a = \frac{2R}{3y};$$

and it will at once be seen that, as the resultant, R, approaches the nearer end, a, of the surface, the maximum unit pressure, p_a, at a, increases very rapidly, and no longer in simple proportion to the distance, x, of the resultant, R, from the center, o, of the joint, as it did (1) when R fell within the middle third, or (2) when the tension is active.

In cases like Fig. E, the maximum unit pressure, a, soon becomes enormous, and it would reach infinity if the resultant, R, however small, could actually be applied at the very edge, a.

All this is indicated by the curved line, s t, Fig. G.

Conversely, the same fact may be stated by saying that, for a given permissible unit pressure, the resultant may approach the edge of the surface more closely when there is tension than when there is none.

Thus (Fig. G) if the max. unit pressure, p_a, must not exceed 4 p, the resultant, R, may be applied at the edge, a, if there is tension, but must be kept back from *a* a distance = L/6 when there is no tension.

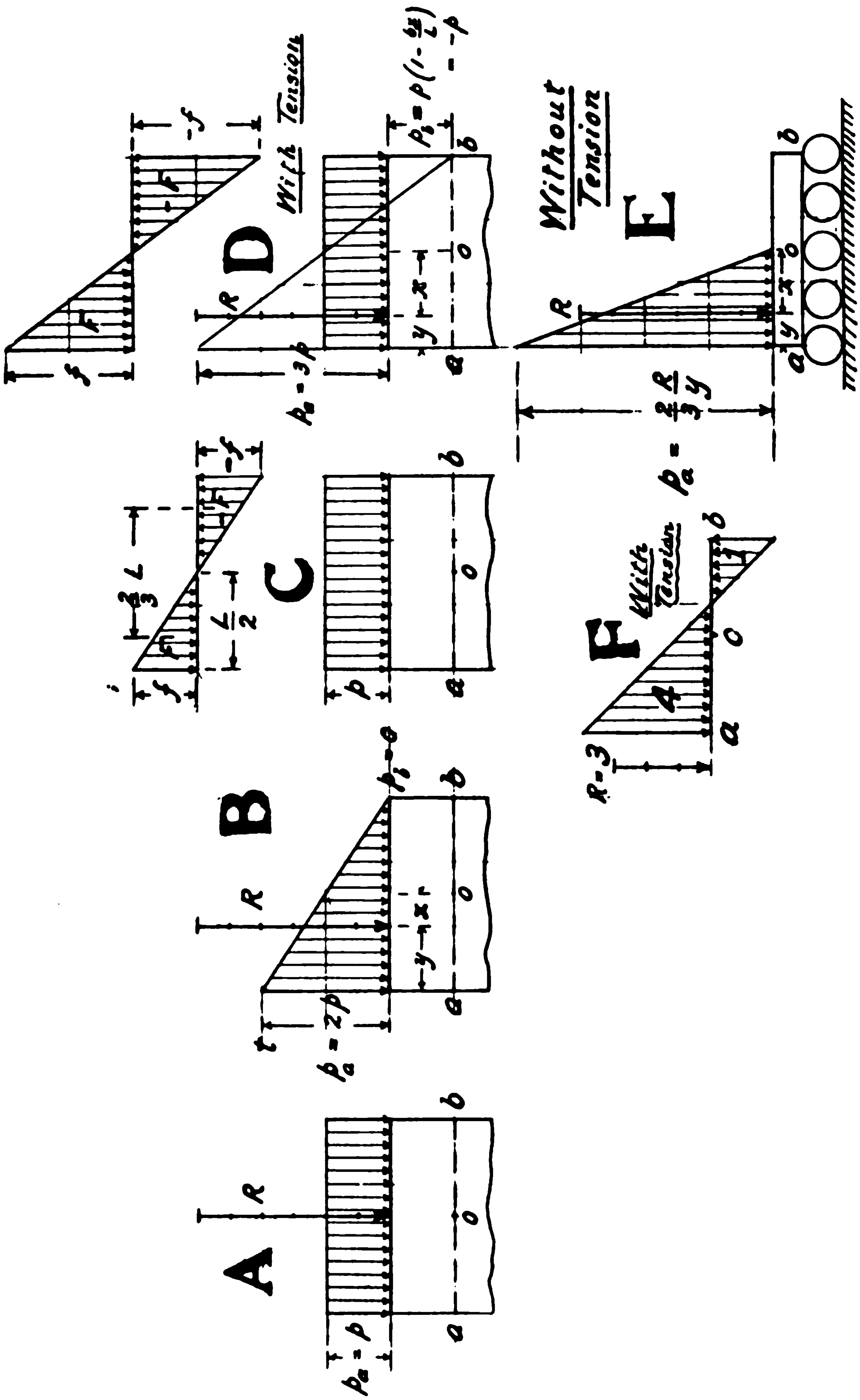
The broken line, m w a, Fig. G, shows the pressures at the other end, b, of the joint, when there is no tension; the pressure, p_b, there diminishing from p_b = p, when R is at the center, o (x = zero), to p_b = zero when x = L/6, and remaining p_b = zero thereafter.

The influence diagram, Fig. G, gives values of p_a and p_b, as follows:

			p_a/p		p_b/p	
	x	y	With Tension	Without Tension	With Tension	Without Tension
Within Middle Third	0	L/2	1	1	1	1
	L/12	5L/12	1.5	1.5	0.5	0.5
	L/6	L/3	2	2	0	0
Beyond Middle Third	L/4	L/4	2.5	2 2/3	−0.5	0
	L/3	L/6	3	4	−1	0
	5L/12	L/12	3.5	8	−1.5	0
	L/2	0	4	∞	−2	0
	7L/12	−L/12	4.5	..	−2.5	..
	2L/3	−L/6	5	..	−3	..
	9L/12	−L/4	5.5	..	−3.5	..
	5L/6	−L/3	6	..	−4	..

It thus appears that, for *any given resultant, R,* applied at *any given distance, x,* from the center, o, of the joint, exceeding L/6, the *greater* maximum unit load, p_a, obtains when the material of the joint is *incapable* of sustaining tension.

It would appear also that, when Professor Rankine said: "there should be no tension at any point of the base," what he really meant to say was that, when the material is *incapable* of sustaining tension, the passing of the resultant beyond the middle third brings dangerous and rapidly increasing *compressive* stresses upon the *compression* side of the joint, and these (by *crushing* the material there) may cause the "tension" side of the joint to open.


A
B
C
D
E
F
With Tension
Without Tension
With Tension

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, September 21, 1912.—The meeting was called to order by Vice-President Plack at 8.35 P. M., with 70 members and visitors in attendance. The minutes of the Business Meeting of June 1st were read and approved.

The Committee on Nominations named by the Board of Directors at the meeting of June 1st was submitted to the Club and approved.

It was moved and carried that in the future smoking be abolished in the Club meetings.

Mr. George S. Bliss, Director of the Climatological Service of Pennsylvania, presented the paper of the evening, entitled, "The Importance of Meteorological Data in Engineering," which was discussed by Mr. John C. Trautwine, Jr., Mr. George S. Cheyney, Jr., Mr. John E. Codman, Dr. Henry Leffmann, Mr. H. H. Quimby, and others.

Upon motion, a vote of thanks was extended Mr. Bliss.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

SPECIAL MEETING, July 11, 1912.—Present: President Hess, Vice-Presidents Plack and Mebus, Directors Halstead, Gilpin, Vogleson, Swaab, and the Secretary in attendance.

The Secretary presented a statement of the financial condition of the Club, which showed a gain in the Income and Expense Account for the first six months of $247.79.

The Finance, Membership, Publication, Library, Meetings, and House Committees presented reports, which were approved.

The Publicity, Public Relations, and Increase of Membership Committees presented no reports, and the Secretary was asked to communicate with the Chairmen of these Committees, asking them to forward a report to the Board of Directors.

The Business Manager's report was read and approved.

The following gentlemen were elected to membership in the Club:

Active: Charles E. Bonine, Harold E. Brunner, Bruce Ford, William J. Hagman, James S. Kunkle, Otto W. Schaum, Herbert L. Towle, M. J. Turnbull, Wm. D. Uhler, A. C. Vauclain, and John E. Zimmermann.

Associate: Charles K. Brown.

Junior: E. B. Callow, Lorenzo S. Cope, James E. Diamond, Fletcher Schaum, and Harry Wickland.

The resignations of Messrs. R. W. Shelmire and E. M. Bassett were read and accepted.

It was decided that the Club officers and officials be asked to submit a statement as to the duties of their offices, to be discussed at the next meeting of the Board.

It was decided to create a special Committee on By-Laws, this Committee to consider suggestions and make studies for the improvement of the By-Laws. The President named the following members to serve on this Committee: S. M. Swaab, Chairman, Charles F. Mebus, Vice-Chairman, J. C. Trautwine, Jr., Edwin F. Smith, Carl Hering, and H. A. Moore.

The President appointed the following standing committees, those in parentheses being new members:

Finance: J. A. Vogleson, David Halstead, (E. J. Kerrick), J. M. Dodge, (S. E. Fairchild, Jr.).

House: F. K. Worley, W. L. Plack, (Richard Gilpin), (G. F. Pawling), H. A. Moore.

Meetings: S. M. Swaab, H. C. Berry, (B. A. Haldeman), Wm. Easby, Jr., J. E. Gibson.

Membership: Chas. Hewitt, F. H. Stier, (David Halstead), Robert T. Mickle, W. P. Dallett.

Publication: Chas. F. Mebus, St. George H. Cooke, (S. M. Swaab), (Wm. Easby, Jr.), (M. E. Hibbs).

Library: B. A. Haldeman, Richard Gilpin, (H. C. Berry), F. N. Morton, M. E. Hibbs.

Publicity: R. G. Develin, E. J. Kerrick, (J. A. Vogleson), F. T. Gucker, G. W. Hyde.

Advertising: D. R. Yarnall, (R. G. Develin), (Chas. F. Mebus), H. Goodwin, Jr., H. B. Allen.

The President appointed the following members to constitute the Lantern Committee: B. A. Haldeman, Chairman, E. J. Dauner, H. E. Ehlers, A. D. Morris, Chas. E. Bonine.

Regular Meeting, September 19, 1912.—Present: President Hess, Vice-President Plack, Directors Halstead, Kerrick, Worley, Develin, Berry, Haldeman, Swaab, Yarnall, Vogleson, the Secretary, and the Treasurer.

The Treasurer reported a net gain to September 1st of $862.39.

Reports from the following Committees were read and approved: Finance, Membership, Publication, Library, Meetings, Publicity, Advertising, House, Public Relations, and Increase of Membership. The Business Manager's report was presented and approved.

The following were elected to membership in the Club: Active, Charles Wirt, H. P. Gant; Associate, George Kendall Myers; Junior, Herbert Ruff.

The following Juniors were transferred to either Active or Associate membership, as follows: Active, H. H. Hewitt; Associate, William Oram and W. J. Taggart.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

VOLUME XXX

EDITED BY THE PUBLICATION COMMITTEE

PHILADELPHIA

THE ENGINEERS' CLUB OF PHILADELPHIA

1913

ologist is studying the relation of smoke and soot and the weather, with special reference to fogs and sunshine, fogs being increased both in intensity and number, and sunshine decreased in intensity and total duration. A botanist is carrying on some special investigations into the effect of smoke and soot on plant life. Economists are making an exhaustive study of the increase in the cost of living on account of the presence of smoke and soot. A chemist and a physicist are studying the nature of smoke and soot. A lawyer is making a study of the legal side of the smoke abatement question in order that an ordinance can be drawn that will be proof against the attacks of the defendants council should it so happen that the courts need be appealed to to bring about an abatement in any particular case. We are optimistic, but not to the point where we think we can dispense with an effective legal club.

But most important of all is the study of the smoke abatement question from the engineer's standpoint. All the other work, except the lawyer's, shows the evil effects and proves that smoke is a nuisance. The engineer must answer the questions, "What can I do to eliminate the smoke from my stack?" and, "Will it pay me?" The latter question must be answered, and in the affirmative, before the first will be asked, in most cases.

Smoke is a nuisance, considered from every standpoint except one. That one is from the point of view of the manufacturer of soap and other cleaning materials. A soap manufacturer said to us, "We're in favor of smoke. The more smoke the more soap," and added, "It is purely selfish in us." He was not anxious that smoke be made in his own plant, however.

The engineer who studies the combustion problem knows that smoke is expensive to the owner of the furnace. The physician knows that certain diseases are more prevalent in a smoky atmosphere, especially pneumonia, catarrhs, colds and other afflictions of the throat, nose and lungs. The economist knows that the cost of living is increased by smoke and soot, the extra expense coming in many ways. We have heard the statement that laundry bills, bills for cleaning of all kinds, and the work for the housekeeper are all increased, called "an old woman's argument," which is simply admitting that his argument cannot be refuted.

"The city is clean to what it used to be." "Our stack does not smoke." "We are not making any smoke." These statements and

PROCEEDINGS

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THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXX JANUARY, 1913. No. 1

PAPER NO. 1115.

METHODS AND MEANS OF SMOKE ABATEMENT

Paper Read before the Club October 5, 1912

By MR. O. R. McBRIDE,
Pittsburgh, Pa.

The object of the investigation which is being made by the Department of Industrial Research of the University of Pittsburgh is to improve the conditions of the city. The slogan of every loyal Pittsburgher is, "Pittsburgh Promotes Progress." In line with this a citizen of Pittsburgh, without expecting any personal gain other than that which comes to every inhabitant from each improvement in the city, and seeking no glory, generously offered to finance an investigation of the smoke problem. He wished this investigation to be more thorough than any other ever made, therefore he placed the problem in the hands of the Industrial Research Laboratory of the University of Pittsburgh, together with the necessary funds for a thorough and exhaustive study of the problem. A large staff of experts has been appointed, each to make a study of the particular phase of the problem for which his experience and training fit him.

Physicians are securing data as to the effect of smoke and soot on the health of the individual who must live in a smoky atmosphere. Architects are determining in just what way and how much the presence of smoke and soot affects their work. A meteor-

are reduced to a minimum and the heat gotten from the fuel is applied where it is wanted. If it is a boiler furnace you want your heat to make steam. If it is a metallurgical furnace you use it to heat the steel, iron or whatever you are working. The problem is then to reduce your losses to the lowest practicable figure.

Heat is lost in some of four ways, viz.: Imperfect combustion, sensible heat carried away by the waste gases, unburned carbon in the ash and radiation.

When carbon is completely burned or to carbon dioxide 14,500 B. T. U. are given out per pound of carbon. When it is burned to carbon monoxide only 4,450 B. T. U. are given out, or a loss of 10,050 B. T. U. for every pound of carbon burned to carbon monoxide. The U. S. Geological Survey (now the U. S. Bureau of Mines) has shown that for every one-tenth per cent. increase in carbon monoxide in the flue gases there is a decrease of two per cent. in the efficiency of a boiler plant, and that a smoky stack is an indication that carbon monoxide is present in the flue gases. They have also shown that the presence of carbon monoxide indicates the presence of unburned hydrogen and some hydro-carbons. On account of the large losses due to incomplete combustion every effort should be made to avoid this condition in the furnace. *Porter and *Ovitz give the loss when the stack is smoking from three to ten per cent. of the heat in the fuel.

If the owner of a plant should take a walk through his plant and see unburned carbon in the ash pile and on investigation found the amount of carbon was equal to the amount of ash, probably some one soon would be seeking employment elsewhere.

The higher figures given above would be more loss than if the ash pile were one-half unburned coal.

It is just as easy to have this same loss or even a greater loss and yet have no smoke. We would not think that a plant is efficient if the carbon dioxide per cent. in the flue gases falls to ten, which means that over twice as much air is passing through the furnace than is theoretically necessary for complete combustion. We analyzed some flue gases recently and the carbon dioxide was only a little above six per cent. The difference between six and ten per cent. in CO_2 means a preventable loss of over ten per cent. of the heat liberated, flue gases being taken at 550° F and air at 90°.

This loss of sensible heat carried away by the waste gases in the average plant is very large. In a test we witnessed recently the temperature of the flue gases just after leaving the last pass of a boiler was fifty degrees F. higher than that of the steam in the boiler. In average good practice this difference in temperature is found to be from one-hundred and fifty to two hundred and fifty degrees F. It is important to make this difference as small as possible as the heat loss from this cause increases with the temperature.

It is also important that the percentage of CO_2 be made as high as possible and at the same time avoid smoke. The theoretical amount of air necessary for complete combustion is very nearly twelve pounds per pound of carbon. If perfect combustion could be obtained with this amount the percentage of carbon dioxide would be twenty and seven-tenths, or the percentage by volume of oxygen in the air. It is not practicable, in most cases, to secure complete combustion with less than thirty-five to forty per cent. excess, due to the inability to secure a perfect mixture of the gases and the short time allowed for combustion. With forty per cent. excess of air we get fourteen and one-half per cent. carbon dioxide. With one hundred per cent. excess air we get ten and thirty-five one-hundredths per cent. carbon dioxide. With two hundred per cent. excess air the percentage drops to slightly below seven per cent. carbon dioxide. When the carbon dioxide percentage drops to between four and five per cent.—a condition not unusual—there is passing through the furnace from four and two-tenths to five and two-tenths as much air as is theoretically required. Just consider the loss due to heating forty or fifty pounds of air five hundred degrees F. for each pound of coal burned! This represents avoidable loss of about five thousand of the fourteen thousand five hundred B. T. U. in the pound of coal. Is thirty-five per cent. of your coal bill worth saving? It is for you to decide how much you can afford to spend, to save it if such conditions exist in your plant. We have been in many plants in which it would pay the owner large dividends to have an expert on combustion do nothing else than look to the carbon dioxide content of the flue gases and work for an increase in its percentage.

Unburned carbon in the ash represents a comparatively small loss, ordinarily. If it is large it will be seen on a close examination of the ash.

Radiation from the setting and boiler surface can be reduced by proper insulation. This loss cannot be entirely eliminated but can be very much reduced.

It is seen from the above that the large losses to be eliminated or reduced are those accompanying the production of smoke or occuring when large volumes of excess air are passing through the furnace. To secure the highest efficiency the air supply should be regulated between rather narrow limits. The best way to do this is to make flue gas analysis a part of the daily routine of the plant Work for a high carbon dioxide percentage and avoid smoke.

As it is the volatile matter in the coal that is responsible for the smoke, its presence in the fuel should be kept in mind when considering the method of operation to be used, as well as when the kind of furnace is to be decided upon.

The types of furnaces which burn anthracite coal to the best advantage are not satisfactory in using bituminous coal. To successfully burn soft coal, that is, efficiently and smokelessly, the furnace needs modifications. Means must be provided to meet the following conditions:

1. The proper amount of air at all times.
2. Provision for mixing air and volatile matter, providing time and space for combustion to take place, making allowance for the expansion of the large volume of gases.
3. Maintaining a high temperature in fire box and combustion chamber.

Under any method of hand firing the rate at which the volatile matter is driven off is exceedingly variable, requiring a proportionately variable amount of air for its combustion. Even if the proper proportions could be maintained it would be of little avail in preventing incomplete combustion and production of smoke, unless suitable provision is made for mixing these gases, providing space for combustion to take place in, and allowing sufficient time. All this would not produce the desired results unless at the same time the temperature of these mixed gases is maintained at a point above the ignition temperature of the chemical compounds of hydrogen and carbon forming the volatile part of the fuel. The ignition temperature of these gases is in the neighborhood of thirteen hundred degrees Fahrenheit.

The conditions in the ordinary hand fired furnace, usually do not conform to the above requirements. Ordinarily the fireman

throws in quite a large charge of coal at one time and he is not so very careful where he places it. Large quantities of the hydrocarbons are driven off in a very short time, the rate at which they are driven off, being greatest very shortly after the coal is placed in the furnace, and becoming less and less as the coal is coked. No hand operated or automatic device has successfully met the demand for so variable quantity of air, therefore the first mentioned condition is not had.

The ordinary boiler is set too low. If it is a return tubular boiler there may be found a comparatively large combustion chamber back of the bridge wall. If piers, wing-walls or other fire brick constructions are found in the combustion chamber, the gases must take a circuitous path and will become more or less thoroughly mixed. Combustion chambers built in this manner are occasionally found. If in good condition and constructed accordingly to a good design, smokeless operation may be had. Care must be taken, however, that the openings or ports in these piers, wing-walls, etc., are so placed and proportioned that the ash carried over the bridge wall will not obstruct the passages for the products of combustion. Several cases have been found where this trouble had been experienced. In addition the cleaning out of the combustion chamber was a very difficult operation, on account of the ash and dust fusing into a glassy cinder on account of the high temperature.

If the combustion chamber is small and the path of the gases comparatively straight there will not be allowed time nor space for combustion to take place. If the hand fired furnace is under a water tube boiler, vertically baffled, and no coking arch or dutch oven used, the path of the gases is very short and little time is allowed for combustion.

If the furnace is lacking adequate space, smoke results from the too quick cooling of the gases. The gases, if they come in contact with the surface of the boiler before combustion is complete, will be cooled much below the ignition temperature. It makes no difference as to how the temperature is lowered or kept low, the result is the same.

You are all familiar with the three systems of firing intended for prevention of smoke, in general use. The coking method of firing, or the placing of the coal at the front of the furnace, either on a dead plate or on the grate, requires for smokeless combustion a large combustion chamber and an arch over that part of the grate

where the coal is being coked. It cannot be successfully used when the fuel is of such a nature that it will not coke well, as for instance the "block coal," mined in some sections. This coal on being heated, crumbles. Other coal forms bad clinkers which give trouble, especially as the coked part, carrying the ash is pushed toward the rear, leaving nearly all the ash and all the clinkers on the back part of the grate where it is with difficulty removed, unless a dumping grate is used.

The alternate method, in which one-half the furnace is fired at a time, the other half having a bed of incandescent coke, is applicable when provision is made to mix the two currents of gases after leaving the fire. For successful operation, a large combustion chamber arranged with fire brick baffles or piers must be used to thoroughly mix the gases.

The spreading method is not satisfactory from either a smoke abatement standpoint or from the standpoint of economy. It requires that very little coal be thrown into the furnace at a time and that it must be spread very carefully. If a large quantity is placed on the hot bed of coke the fire is cooled too much and at the same time such large quantities of volatile matter are driven off that prevention of smoke cannot be obtained. This method is less desirable than either the coking method or the alternate method. The air admitted when doors are opened is destructive to both boilers and setting, besides cooling the furnace below the ignition temperature of the gases.

The use of steam jets is not to be recommended. They are not economical, unless very carefully used. In most cases, they produce lower efficiency than is obtained without their use. By their inefficiency they have done more damage to the smoke abatement movement than they ever did good in abating the smoke. The introduction of steam into the furnace is a poor policy as it cools the furnace. It is the direct cause of water gas and excessive quantities of carbon monoxide, free hydrogen, and hydro-carbons in the waste gases, all of which lower the efficiency. The claim is made that the hydrogen is burned again—and the heat returned to the furnace. Even if it is all burned, which we do not admit, the heat required to raise the temperature of the steam from that in the boilers to that of the flue gases is lost. The only advantages obtained by the use of the steam jet are the thorough mixing of the gases in the furnace, and the introduction of air over the fire, sometimes.

Automatic Stokes

Automatic stokers are advantageous in so far as they operate under the above mentioned conditions for high efficiency and smokelessness and in addition they have the advantage that in general, a cheaper grade of fuel can be used and the labor expense can be reduced.

For small plants the cost of installation per boiler horsepower is greater than for medium sized and large plants. In small plants the reduction in labor is small and it happens in very small sized installation that there is no reduction in the labor. They cannot be installed in very small plants economically. There are certain conditions of fuel and required service which will recommend one machine over another. In selecting the type and particular example of that type for installation, it is a good thing to first study the conditions to be met and the cnditions of good service to see if the contemplated installation is the best for the conditions.

Automatic or mechanical stokers are of two general classes, viz.:—Underfeed and overfeed. The overfeed has two distinct types, viz.:—chain grates in which the grate has a motion of translation and carries the fuel through the furnace and dumps the ash, and the inclined grates, the individual grates of which have a small motion which agitates the fuel, and the fuel under the influence of this agitation and gravity is moved from where it enters to the point where the ash is to be discharged.

In the underfeed type the green coal is pushed under the bed of the fire, and the grate is not exposed to the hottest part of the fire. Very hot fires can be obtained with this type of stoker which makes thetm very adaptable to metallurgical work.

There is in Pittsburgh a plant engaged in making forgings up to three or four hundred pounds, finished.

Ten or twelve years ago the superintendent thought a mechanical stoker could be used advantageously for his heating furnaces. He installed an underfeed stoker and found, first, he doubled the output from the furnace the first day and has gotten a better result at times; second, and most important, from the smoke inspector's point of view, there is no smoke. Needless to say it was only a short time till he had all his furnaces equipped with automatic stokers.

When the underfeed is used for boiler service, a very uniform boiler pressure is had, and if the installation is a good one, heavy overloads may be carried. As this type must depend on forced draft, there is a good chance for securing the proper proportions

of air and coal. The manufacturers of this type of stokers claim that when the apparatus is once adjusted the proportions are maintained, no matter at what rating the boiler is operating.

There are three serious points which are raised against the underfeed stoker. The fan engine must be installed in duplicate to guard against a shut-down. The power for operation is large and in some of the makes the cleaning of the fires is a very hot and disagreeable task, and the saving in labor is none.

The chain grate is always installed with an arch or roof over part of the grate, and usually it is set with a dutch oven. The grate is exposed to the hot part of the fire only a portion of the time. In the best forms the chain is made up of a large number of links which form the grate surface. In passing over the sprockets these links rub against one another, cleaning the grate of any clinkers which may have formed.

The fuel is carried from the coolest part of the furnace through the hottest part, all the volatile matter being driven off while the fuel is yet under the coking arch. As a smoke preventer, this grate is excellent if set properly and operated by intelligent men. With proper operation, very good results are obtained with the best makes of this type of stoker. It has the disadvantage of not being quick to respond to sudden changes of load, as for instance, the starting or stopping of the engine for large rolling mill work, the engine using from ten to twenty-five per cent. of the steam being made. The problem of avoiding excess air is difficult with this stoker; the excess air is liable to come in at the rear of the grate on light loads and also at the sides on any load.

It is difficult to get a fireman to properly regulate his draft according to the load, which is fatal to efficiency, and on heavy loads, fatal to smoke prevention. Of the inclined grate (i. e., gravity feed or avalanche) stokers there are two distinct types. In one, the fuel is fed in at the front, and by agitation it slides down over the bars which present the appearance of a flight of steps. This type offers the serious objection that the fuel hangs and when it is forced to to move it moves too rapidly and slides into the hottest part of the furnace, producing smoke, and usually lots of it. This lack of uniform movement causes air holes in the fire—enemies to high efficiency. It is usually set with little or no coking arch, a necessary part of a smokeless furnace. If the arch is made long enough to be of any value it will soon burn out. We have it on good authority that the Smoke Inspection Department of Chicago

will not approve of some settings having this kind of stoker. Firemen will use the poker or slicing bar from the side doors unless these are bricked up. We have seen the small holes for using the poker in the front bricked up.

There is another form of gravity feed stoker in which the coal hoppers are at the sides of the furnace. A coking arch covers the whole grate and in some cases reaches back beyond the grates. This furnace is not so bad an offender as the form just mentioned. This is due mostly to the presence of the coking arch or roof over the grates. Due to the irregular movement of the coal down the grates, holes are found in the fire, and poking is resorted to . This form has a clinker grinder in the point of the V made by the grates. With a badly clinkering coal a large clinker will form over this clinker grinder and stops the discharge of ash and clinkers. These large clinkers must be removed through the front door of the furnace, before the furnace will operate properly. This is a particularly disagreeable operation.

We recommend the use of mechanical stokers wherever they can be used. The resulting economy, if they are set properly and well operated, will pay large dividends on the investment, especially in plants of three hundred horse-power up. We also recommend the flue gas analysis, if it is continuously and conscientiously carried on, and an effort is continually made to better the plant by correcting all things which it indicates as faulty.

It will do no good, no matter how good an installation you have, if intelligence is not also available in the boiler room. To have an economically operating plant, a much better class of labor must be had than is usually found in the boiler room. If we can convince the men who are responsible for the policies of the companies that the expenditure of a certain sum of money will produce, in their plants, the results obtained in other plants where efficient and smokeless operation are had, the smoke problem will be solved in most cases. There will be a few whom we will have to use a strict ordinance against, just the same as we must have laws to protect society from the naturally perverse.

We have tried to show some of the principal features of the smoke problem and that it can be solved, producing clean cities as well as larger profits to the owners of the various plants. We often hear the expression, "Smoke means prosperity." We think it should be changed to, "Smoke means ignorance, carelessness and waste."

THE INTERNATIONAL SMOKE ABATEMENT EXHIBITION *

PAPER NO. 1116

HELD IN LONDON, MARCH AND APRIL 1912

BY GEORGE H. PERKINS, LOWELL, MASS.

(Read October 5, 1912)

Mr. George H. Perkins, Head of the Engineering Department of the Lowell Textile School; represented the City of Lowell, The American Society of Mechanical Engineers and the Department of Commerce at the Conference in London.

An International Smoke Abatement Exhibition and Conference, under the auspices of the London Coal Smoke Abatement Society, was held at the Royal Agricultural Hall, Islington, London, March 23 to April 4, 1912.

The object of the exhibition was to make a comprehensive display of the most approved modern methods and devices for the abatement of coal smoke, applicable either to industrial plants or domestic fires. There were also exhibits showing the injurious effects of smoke deposits upon health, building materials, works of art and vegetable life, with the view of creating an active and intelligent public sentiment on the importance of this widespread nuisance.

The educational work was supplemented by a series of conferences which were well attended by official delegates from most of the principal cities of England and Scotland as well as from Germany, Holland, Sweden, and other foreign countries.

Thet exhibition attracted much favorable attention from the press and general public, and upon the whole was considered a success. The great coal strike which was at its height at the time, while interfering with the attendance and delivery of exhibits to some extent, tended to increase public interest in the affair and to divert attention to the larger question of the conservation of the coal supply.

* Courtesy of the American Society of Mechanical Engineers.

Present Status of the Smoke Problem in England

Smoke has been a recognized nuisance in England for nearly a century. As early as the year 1819, Parliament appointed a committee to investigate this question which reported that effective smoke abatement devices existed and should be used. The public health acts of 1875 and 1891 included sections covering smoke abatement which are the only present laws on the subject. These statutes have not proved satisfactory as they are not sufficiently definite and do not make provision for their proper enforcement.

Practically all the effective work done in abating the smoke nuisance has been accomplished during the past 15 years. The great improvement in atmospheric conditions, as far as London is concerned, has been due principally to the following agencies:

a The electrification of all the underground railways formerly operated by coal burning locomotives.

b The rapid increase in the use of gas appliances for heating and cooking. When authorities agree that more than one-half of London's smoke comes from domestic fires burning soft coal, the following figures are significant:

Year.	Number of Gas Appliances in Use.
1891	46,000
1896	223,000
1901	445,000
1906	989,000
1911	1,494,000

c The work of the London Coal Smoke Abatement Society, a voluntary association which has for its objects the following:

1 To aid in enforcing the existing law through the local sanitary authorities, by the employment of inspectors who, after investigation, shall report offenders to the proper officials.

2 To promote and encourage all voluntary efforts to abolish smoke from private dwellings and to investigate the best means for effecting this object.

3 To obtain particulars and evidence of methods of dealing with smoke nuisances at home and abroad.

4 To publish information on matters relating to smoke nuisances, stimulate invention through the offer of prizes

and to conduct tests on heating, cooking and stoking apparatus.

5 To effect the amendment of the present laws with the object of making them more efficient.

Other societies of the same character have been organized in some of the larger cities and are doing effective work along similar lines to that of the London society. One of the most active of these is the Smoke Abatement League of Great Britain which has its headquarters in Manchester and branches in many of the other large industrial centers.

The most direct evidence of the improvement made in smoke abatement in recent years is in the record of observations of atmospheric conditions taken in many of the large cities. The "black fogs" once so prevalent in London and which have been proven to have been due largely to smoke are to-day practically unknown. The winter sunshine of London is to-day about 40 per cent. of that observed in the country districts, which is a figure double that of 30 years ago.

In nearly all of the larger cities a marked improvement along similar lines has been made each year and through the agencies already mentioned. In the manufacturing districts particularly, the boiler users are taking increasing interest in this matter, realizing that it has an important influence upon the efficiency of their plants. The public is also aroused to the situation and the urgency and practicability of smoke abatement seem to be generally appreciated.

Summary of Papers Presented at the Conference

The papers presented at the conference may be grouped under thet following heads:

A Smoke pollution

1 Economic and Artistic Aspects.

2 Effects on Plant Life

B Smoke Abatement.

1 Organization of Preventive Action

2 Physical Principles of Smoke Abatement

C Laws and Legislation.

1 Proposed New Legislation.

2 Administration of Existing Law

(*A*-1) *Economic and Artistic Aspects.*

Under this head papers were read treating of the effects of smoke upon building materials, mural and house painting, ornamental and structural metal work and also the measurement of soot deposits.

Examples were cited of the disintegration of the stone in various buildings due to sulphuric acid in the atmosphere. This acid is formed from the union of the oxidized sulphur compounds, resulting from the combustion of coal, with the moisture of the atmosphere. An analysis of stone taken from St. Paul's Cathedral showed 74 per cent. of calcium sulphate, the original stone being calcium carbonate or limestone. Similar results were obtained on samples taken from Westminster and other well known and historic structures. Limestone appears to suffer more than any other variety of stone while granite is not seriously affected.

The ecect of smoke on mural and fretsco paintings was due to a similar action, the plaster beneath the pigments losing much of its binding power by the chemical change taking place. The effect upon house paint is also very pronounced, particularly on the lead paints. Practically all outside work must be repainted at least once a year. Zinc oxide paints were shown to be more stable than lead pigments against the action of atmospheric acids.

The most serious effect upon metal work is the corrosion of structural steel. Several collapses of iron roof trusses, notably that of the Charing Cross Station, have resulted from this cause. In some instances it was found that about 10 per cent. of the iron had been dissolved into ferrous sulphate. The corrosion of uncovered iron or steel wire has also been observed and found to be extensive.

During the past year the soot fall of London has been carefully measured by means of specially devised soot gages. This work has been in charge of the officers of the Smoke Abatement Society and the extraordinary results obtained may be summarized as follows:

The total yearly deposit from the atmosphere was 650 tons per square mile, or a total of 76,050 tons per annum for the entire administrative county of London of 117 square miles. This figure includes 8000 tons of sulphates, 6000 tons of ammonia and 3000 tons of chlorides, the balance being carbon and tarry products. The deposit per square mile at Surrey, on the border of the metropolitan

area, was only 195 tons per year, or less than one third that of London proper, showing clearly the comparative purity of country air.

(*A*-2) *Effects on Plant Life*

Evidence was given by the authorities in charge of the Kew Gardens and other parks as to the difficulty of maintaining vegetation in smoke affected districts. Only a few hardy plants and shrubs will survive the winter season in the large cities. The main effects of smoke on vegetation are due to the following:

1 Reduction of light and heat from the sun.
2 Soot deposits excluding still more light.
3 Tarry deposits blocking the pores of the plants.
4 Acid deposits lowering the vitality of plants.

The effect upon health of smoke polluted atmasphere was clearly shown by figures given from Glasgow, where a study has been made of the effect of smoke fogs upon the death rate from bronchial diseases such as bronchitis, pneumonia and pleurisy. The deaths from these diseases alone increased at a remarkably rapid rate during prevalent fogs and could be traced to no other source.

(*B*-1) *Organization of Smoke Abatement Work*

The work of the various smoke abatement societies was described in detail and many suggestions were made regarding the possible future study of this problem. The majority of these suggestions were along the line of determining the actual economic loss to the community caused by smoke, it being generally conceded that the engineering side of the question is well in hand and sufficiently well developed to meet practically all conditions provided careful study is made of the factors involved.

Some of the elements in the economic loss to a city are as follows:

1 Added cost of artificial illumination.
2 Added cost of painting exteriors and interiors.
3 Added cost of laundering and other cleansing.
4 Damage to goods in stores and factories.
5 Effect of gloom upon the efficiency of workers.

Recognition was made of the splendid work done on smoke abatement in Cleveland, Ohio, and Chicago, Ill., where the progress made within the past five years has been remarkable. In both of these cities the problem is handled by efficient depart-

ments of the municipal governments furnishing a most excellent example of honest, effective and thorough public service. These two cities are without question well in advance of any other American municipalities in the matter of smoke abatement.

(*B*-2) *The Physical Principles of Smoke Abatement*

The papers presented under this head covered various phases of the subject, including the effect of smoke upon steel making, losses due to incomplete combustion, hand and mechanical firing, the manufacture of smokeless fuels and the construction and operation of producer gas plants. The production of steel without objectionable smoke was held to be practicable, without affecting the quality of the steel.

Results of tests weret given showing the loss due to unburned combustible matter in smoke and that due to a non-conducting layer of soot upon the surfaces of boiler tubes and plates.

The value of trained firemen was especially emphasized and the subject of hand firing and conditions under which it might be successful were discussed. It was proposed to add to the present license for firemen, a certificate of competency based upon a knowledge of proper conditions for perfect combustion, heating value of fuels, etc.

(*C*) *Laws and Legislation*

The larger part of the matter presented under this head would not be applicable in this country for obvious reasons. A strong plea was made, however, for uniform and definite legislation on smoke abatement. The principal paper in this group urged the appointment of a royal commission to inquire generally into the subject of smoke emission for the purpose, if possible, of having a stringent general law passed by Parliament. It was suggested that this royal commission, if appointed, be directed to inquire:

1 What standard, if any, is desirable as to the color or density of the smoke which should be deemed a nuisance?

2 How the color or density of smoke can best be identified?

3 Are the fines at present inflicted upon offenders sufficiently adequate to act as deterrents?

4 Who should be punished, the owner of the works, the engineer in charge, or the stoker, when smoke nuisances result from the careless manipulation of well equipped installations?

5 Should any industries receive special treatment?

6 Should Government inspectors be appointed to act in regard to the emission?

7 Should Government premises be placed under the obligation to prevent smoke nuisances?

8 Ought any hourly or other time limit be fixed during which black or other smoke may be permitted to issue from factory chimneys?

9 Should all cases be heard by stipendiaries? (Paid Magistrates.)

10 Can the issue of an unreasonable quantity of smoke be prevented except in cases of accident or breakdown?

11 Can it be shown that the installation of proper appliances generally results in economy as is contended by "smoke abaters"?

12 The incidence, intensity and duration of fogs and their effects on health.

13 The influence of smoke on health.

14 The damage of smoke to buildings, works of art and property generally.

15 Foreign efforts to cope with the smoke nuisance.

16 How far is it possible by smoke abatement to conserve the coal supply?

17 How far is it practicable to deal with the smoke from private dwelling houses?

Classification of Exhibits

The exhibits may be classified into the following groups:

a Boiler furnaces; special grate bars and furnace construction; mechanical stokers of all types; smoke preventing devices of various kinds; fuel economizers; briquette making machines.

b Suction gas plants; gas and oil engines.

c Open coal-fere grates; stoves and ranges of all kinds; draft regulators and other smoke preventing appliances for domestic fires.

d Gas stoves and grates; gas heating and cooking appliances.

e Electric heating and cooking appliances.

f Testing devices, including anemometers, tintometers, soot gages, automatic gas analyzing devices, etc.

g Fans and other appliances for the removal of dust of various kinds from industrial plants.

h Smokeless fuels, both natural and artificial.

While there was little essentially new in the principles underlying the various devices exhibited, there has been a marked improvement made within a few years in their design and mechanical construction. There was also evidence of an appreciation and careful study of the theoretical side of the question which has undoubtedly contributed largely to the relatively better results obtained in recent years. The exhibits were so numerous and varied that only the most important will be mentioned.

Mechanical Stokers

The stoker which appeared to bet considered the best adapted for the prevailing conditions in England is the chain grate type.

When used with the proper fuel, preferably bituminous slack, this type appears to meet the requirements of smokeless combustion more nearly than any other device, particularly with water tube boilers. The best sample of this stoker exhibited was by the Babcock and Wilcox Company.

A number of types of coking stoker were shown, the best being those made by J. Hodgkinson of Salford and E. Bennis of Bolton. These stokers are better adapted to the Lancashire type of boiler, since they are not readily forced. In their action a reciprocating ram, mechanically driven, and located in the bottom of the hopper, forces a small quantity of fuel on to a "dead" or coking plate at each forward stroke. While the fuel remains upon this plate the volatile products are driven off and the coked coal then drops upon the grate bars which are of a sliding type and actuated by a cam motion on the front end. The mass of the fire is constantly carried toward the rear of the furnace by an intermittent and simultaneous movement of all the bars, the return stroke of each bar being independent.

There were a number of forms of sprinkler stoker shown which, although of ingenious design, have not proved satisfactory where smokeless operation is desired.

While there were no underfeed stokers exhibited, there are a number of English machines of this class giving satisfaction under the proper conditions. The best known are the Vickers,

Bennis, Underfeed and the Proctor. This type of stoker is not so well adapted for use with the average fuel available in England and is not so extensively used as in America.

Patent Furnaces

There were many exhibits under this head, only a few of which possessed real merit. The majority of these appliances consisted simply of properly controlled steam jets with special forms of grate bars. There were a few good devices for the automatic regulation and timing of the supplementary air supply, both over the fire and below the grate. The best of these was the Kowitzke furnace which was excellently designed and simple in operation.

Various types of furnace construction, designed to effect a better mixing of the gases, were also shown. The Gregory patent furnace makes use of a supplementary jet of vaporized fuel oil ejected over the fire, which is claimed to add materially to the efficiency.

A special boiler known as the Bettington is dsigned to allow the use of a mixture of air and pulverized fuel or coal dust, introduced by air blast at the bottom of the boiler which is of the vertical type. This boiler is intended for use at mines or wherever fuel of a finely divided character is available.

Miscellaneous Devices

A device for the optical analysis of the gases of combustion by means of a interforometer was shown by Carl Zeiss and Company. It is based upon the principle that the refractive power of the gases is dependent upon the content of carbon dioxide. A gas refractometer is so calibrated that the analysis of the gas may be read on the scale bysimple inspection. A special form of tintometer was also shown in a portable form for gaging the density of smoke or fog.

The numerous forms of appliances adapted for domstic uses, all showed improved features, but need not be described here.

Other interesting exhibits included "Coalite" and other artificial smokeless fuels, spark and soot catching chimney cowls and special chimney construction for effecting a dilution of the smoke as it is emitted.

Conclusions on Smoce Abatement

In judging of the merits of the various types of mechanical firing appliances exhibited, it should be recognized that all of these devices were designed for local conditions and for burning English or Scotch coals. These fuels cost from $2.50 to $3.50 per ton at the plant, contain from 30 per cent. to 35 per cent. volatile matter and 11,000 to 13,000 b.t.u. per lb. In these respects they correspond to our Illinois or other western coals. This class of fuel is not available in New England for economic reasons. The freight charges on coal in this section amount to about $3.00 or nearly three quarters of the average cost of fuel per ton. It is therefore not feasible or economical to burn any but the highest grade of bituminous coal in this part of the country for industrial purposes. This class of fuel should contain about 14, 000 b.t.u. per lb. and not over 20 per cent. volatile matter. On the chain grate, for example, which gives excellent results in England, this coal could not be burned satisfactorily. It would be impossible to maintain a proper ignition temperature with such a low per cent. of volatile matter without an excessive draft which would give large losses to the stack. The chain grate is meeting with success in this country wherever fuel of the lower grades is available.

Of the other devices, perhaps the most important are those automaticaly controlling the air supply, both over and under the fire. These eliminate the personal factor of the fireman and should be effective on any type of hand-fired furnace.

In conclusion, smoke abatement may be best effected in the present state of the art of fuel burning by thorough consideration of the following conditions. Careful attention to one or all of these factors by competent engineers will increase the efficiency of any plant and with efficient combustion comes smokeless operation.

1 Selection of a suitable fuel with provision for maintaining same at fixed standard of heat value.

2 Careful scientific study of the conditions prevailing in the plant, including draft, composition of gases, temperatures, etc.

3 Design or selection of type of furnace or apparatus best adapted to meet these conditions.

4 Proper construction or installation of same.

5 Careful selection of operating force.

6 Suitable instrumental aids or guides for the fireman and responsible engineer.

7 Frequent and thorough inspection to insure maintenance of highest possible efficiency.

WORK OF THE HAMBURG SMOCE ABATEMENT SOCIETY

Among the delegates present at the London conference was Herr Nies, chief engineer of the Vereins fur Feuerungsbetrieb und Rauchbekampfung, of Hamburg, who later extended to the writer, in Hamburg, many courtesies which brought him into contact with the work of the society.

The Hamburg society, which was organized in 1902, is essentially defferent from other organizations of this character in the following important features:

a It is an entirely voluntary organization of manufacturers and other boiler users bound together only by a common desire to obtain greater efficiency and less smoke from their power plants.

b The working staff of the society is composed wholly of technically trained engineers.

c All boilers owned by members are under the systematic and scientific control of the expert staff of the society.

d All members benefit mutually by the published results of all tests and investigations made by the engineers.

e The economy of smokeless combustion is the cardinal principle and the members have been convinced of this in a most practical manner, in the savings effected in a fuel consumption by their co-operative effort.

The society now numbers 436 members, representing 1381 boilers. The annual dues of members are small, being only $5 and $5 additional for each boiler in their plants. The society is entirely self-supporting and draws its funds from three sources, annual dues, payment for special work or reports, and payments for outside work.

The education and control of firemen in the proper performance of their duties are also undertaken by the fireman instructors on the staff of the society.

Comparative tests of fuels, smake preventive devices, etc., are carried out by the engineers and the results are circulated among

the members. Advice is also given on purchase of fuel, the buyers being educated by the engineering staff to appreciate the importance of this matter.

The egineering staff of the society consists of a chief engineer, four assistant engineers and eight trained firemen who act as fireman-instructors. For the chemical and thermal analysis of fuels, the society avails itself of the testing laboratory of Dr. Aufhauser, at Hamburg. This laboratory, which is one of the most complete of its kind in Germany, tests about 2000 samples of fuel annually. Dr. Aufhauser also edits a periodical called "Smoke and Dust," to which the engineers of the society are frequent contributors.

The work of the Hamburg society is as practical and effective scientific work as is done anywhere along these lines. The efficiency of the plants, under its control, is materially bettered and maintained, the owners derive a substantial economic gain and the smoke problem is solved without the aid of the usual unsatisfactory legislation.

DISCUSSION

Chairman.—I will call upon Dr. Herman B. Allyn, representing the Philadelphia County Medical Society, who will talk upon the subject from a sanitary point of view.

Dr. Herman B. Allyn.—One of the most gratifying things is to learn that one of the most important cities of the State has taken up an investigation which will be a benefit to the entire country. It does seem that an investigation of this sort should be so thorough that nothing will be left out, nothing left undone, and I very much hope that the commission having this matter in charge will be able to report on it at no very distant date.

Regarding the collection of dust and soot, one might consider it from several points of view. In the first place, the effect of smoke and soot upon buildings and upon draperies and hangings, and the effect of obscuring the sunlight; or one might consider it from a purely economic standpoint, the effect of smoke and soot in its depreciation of property, by the chemical action of soot and also the enormous waste, something like 30 or 40% if I recollect.

But the effect of smoke and soot upon the health is a matter which naturally interests me most, and in this respect, of course, we are not able to do what Mr. McBride's experiment with vegetables has done, because until after a person's death we are not able to tell how much smoke and soot he has absorbed, so it is not easy to state in regard to any individual or individuals just how much damage has been sustained. We have known, however, that in mining communities, the miners have absorbed sufficient coal to transform their lungs into a material about as black as the hats they wear, but the damage sustained is difficult to estimate.

The problem may be well likened to that which we had with respect to typhoid fever in Philadelphia before the advent of filtered water. We felt that the outbreak of typhoid was due to the contamination of the water, but you will remember that it was very rarely possible to find the typhoid bacilli in the water. We do know, however, that after filtered water came, the typhoid almost disappeared. I do not know that I have seen a case of typhoid fever which developed in the district in which I live in West Philadelphia since we have had filtered water. I know, of course, that there have been cases among people who have returned from Atlantic City or other summer resorts, the disease having been contracted while they were away. But cases of city origin in the districts supplied with filtered water have been very few.

We are in somewhat the same position regarding the evil effects of smoke and soot. We believe they are injurious, but we may not be able to prove it conclusively until we compare the city health after smoke and soot are nearly abolished with health conditions as they exist today.

Now in regard to the health of the individual. If we could know, for instance the health of Pittsburgh before and after, as we will be able to do some day, we could show that such and such ill health was due to smoke and soot. In Germany there are certain districts, such as Essen, which are very smoky, and there are others which are not, and the differences in prevalent diseases are striking. Louis Ascher, who investigated health conditions at Essen where the Krupp Works are, and compared them with those at Krefeld, an enterprising town in the same district of Rhenish Prussia, but given up to textile manufactures, found quite a considerable difference. What he found was that in this textile district of Krefeld, where they make tapestries and silks, there was a larger morbidity from tuberculosis, whereas in the Essen district they had a larger morbidity from very acute lung infections, namely, pneumonia, bronchitis and the like. The difference was, as I remember, about 130 as compared with 40, showing greater liability to acute lung affections in the district where there was the most smoke. I wish we had some definite statistics in regard to our own country.

Ascher did another interesting piece of work. He investigated the effect upon animals who were kept in a smoky atmosphere and then inoculated with a disease. He found that they died in a much shorter time in such smoky atmosphere. He also reports that in regions where there is a great deal of smoke, while there is less tuberculosis as compared with the district where textile industry predominates, but the air is not so smoky, yet the duration of life is shorter for those who have tuberculosis, showing that smoke has a distinct influence upon the duration of the life of the tuberculous patient. That is, he has fewer years to live in a smoky atmosphere than in a clear atmosphere.

In a lecture on Smoke Abatement, delivered at the International Health Exhibition, in 1884, by Ernest Hart, he quotes Sir. Wm. Gull, as follows: "It is clear that smoke and fog, not only touch, but kill the life of man." Sir Andrew Clark, Sir Henry Thompson, Sir T. Spencer Wells, Prof. Corfield, Dr. Ransome (of Manchester) and other eminent medical authorities have added their testimony:

"Sir Andrew Clark writes to me: "I, for my part, have no manner of doubt that a smoke-laden atmosphere exercises an injurious influence upon the health,

moral as well as physical, of those persons who dwell in the midst of it. A smoky atmosphere, both by its exclusion of light and by the irritating particles suspended in it, is hurtful to the lungs and air passages; it aggravates the discomforts of sufferers from heart disease; it deepens the distress of the nervous; it lowers the tone of general health; it adds perils to the sickness of the aged; and it materially diminishes that brightness and buoyancy of spirits which contribute so much to the power and gladness of life.'"

During the five years, 1868–1873, the average death-rate from diseases of the respiratory organs was 2.27 per 1,000 in Westmoreland (one of the healthiest counties in England) and 2.51 in North Wales.

For the whole of England and Wales it was 3.54; for Salford, 5.12; and for the Registration district of Manchester, 6.10. Taking, however, the township of Manchester alone, it appears that in 1874, the last for which returns have been published by the Registrar-General, the death-rate from these diseases amounted to 7.7 or three times the average of healthy districts, and more than double the general average for town and country districts—healthy and unhealthy. If, therefore, the rate could be reduced to the average for all England, there would be an annual saving of more than 700 lives in Manchester alone.

In 1873, the deaths in Westmoreland from diseases of the respiratory organs were 13.7 per cent.; in all England and Wales, 17.2 per cent.; in Birmingham, 18.2; in Liverpool, 18.7; in Sheffield, 21.0; and in Manchester, 21.6 per cent.; but excluding the out townships, the rates in the township of Manchester alone amounted to 23.2 per cent. It appears therefore, that Manchester suffers more from diseases of respiratory organs than any other town or city in England; and it may be safely affirmed that if no means can be found of reducing the number of deaths from this class of diseases, it is hopeless to expect that any material improvement can be made in the general state of the public health, or any sensible reduction effected in the general death-rate of the city. (Extract from Manchester and Salford Sanitary Association Report.)

There is reason to fear that our condition may, in the course of time, be as bad as those in the smoky cities of Manchester and Birmingham I have mentioned. The remedies are education and an aroused public sentiment against smoke.

Dr. Anders.—Speaking in connection with my colleague, Dr. Allyn, as I had the privilege of doing once before on an occasion when this question was brought up, I can only reiterate and emphasize some of the points I tried to urge at that time, and those that have also been touched upon tonight by Dr. Allyn.

There is no question but that the undue prevalence of smoke is not simply a matter of waste and extravagance from an economic standpoint. It is not simply a matter of defacing public buildings, the destruction of fabrics, furniture, clothing, etc., things which appertain to domestic life; it is not, as I understand it, a nuisance to public comfort only, but it is distinctly a menace to public health; and as representatives of the profession and representing the societies we do, it is our duty to bring the matter to your notice tonight. There are those connected with the laboratory who have failed to notice the influence smoke has on the public health; but those who are practising physicians cannot but believe definitely that smoke prevalence counts for a great deal in its influence upon the public health. Of course, as a direct cause of disease it no doubt ranks decidedly

the smoke problem. To make political appointments, and to carry on the work as a political proposition, expecting to clean up the smoke problem in two years, three years, or four years, is not the right way to go about it; the political factor must be eliminated. I believe it necessary to start out with a twenty-five year proposition, nothing less. In Cleveland, Pittsburgh, or in St. Louis, it may take even longer. In Philadelphia we ought to start immediately. I have not been here more than three times in my life, and I thought Philadelphia was a clean city until today when I was much astonished, in looking from a high building, to see the amount of smoke you have here. It seems to me it is necessary for you to get busy before the conditions get thoroughly bad. The smoky condition here is creeping in slowly and ought to be checked. It is entirely possible to burn soft coal without making smoke, but it takes an exceedingly careful study of the type of furnace and other conditions relating to draft, etc. A couple of examples will illustrate.

In tests made by the Government in connection with torpedo boat service, attempts were made to use briquettes made from bituminous coal in an effort to eliminate smoke, so the boats could steal into harbors without being detected by a line of smoke behind them. Under the bow boilers the raw coal was used, and in the stern furnaces the briquettes were used. The draft carried with the briquettes was only half that required for the raw coal. The steam gauges on the boilers in which the raw coal was carried did not get up to full pressure, while the boilers used with the briquettes were blowing off during the entire trip with the boat making a speed of 30 knots. There was a slight trail of smoke with the raw coal, and tremendous volumes from the briquettes from which no smoke was expected. The combustion took place all the way up the stack and way beyond the stack. The question was one of improper combustion space for the fuel used.

If you go into the Government Testing Laboratory at Pittsburgh, you will find there a combustion chamber 40 feet long, with a Murphy stoker. They burn there 40, 50, 60 and 65 pounds of coal per square foot of grate area per hour and get no smoke. Perfect combustion is established before the gases reach the end of the combustion chamber. The same thing can be done elsewhere. A given coal can be burned and burned efficiently, with proper settings and proper furnaces.

I am not altogether in sympathy with trying to create too strongly the impression that smokeless combustion is a big money saver. It is a money saver indirectly; for instance, in Cleveland it has been estimated that the annual cost due to incidental troubles from smoke amounts to $12.00 per capita or about seven and a half million dollars per year. But then comes the question of whether a manufacturing plant is working more efficiently when it is making smoke than when it is making no smoke. There are conditions under which you can run your plant without smoke, and these are the ideal conditions, but the average manufacturing plant, as manufacturing is done today, is developing much more rapidly than the boiler equipment and the power plant itself, and the result is that the owner is trying to get two or three times the designed capacity out of the boiler plant in order to get efficient returns from a manufacturing standpoint. There are two problems: One, efficiency from the operation of the coal; and the other, efficiency from the standpoint of the manu-

facturer. The smoke inspector may say "you ought to spend thousands of dollars to rebuild the power plant." As I said before, I think, smoke elimination is a 25-year proposition, and if I were going at the thing, I would outline something like this: Get public sentiment with you, eliminate politics, and appoint a commission of engineers to attack the whole problem from an engineering standpoint. I would not fine everybody that makes smoke now, but would frame laws in such a way that every new plant that goes in and every old plant that is remodeled must be adapted to the local coals which are to be used. In this way the problem will be gradually worked out, although it will take years, because there are a great many boilers that have just gone into new plants and a good many plants that have just been remodeled.

Further than this, there are very few engineers in the country today sufficiently familiar with the problems of combustion to enable them to design with guaranteed success furnaces adapted to the wide variety of fuels. Careful researches and investigations are already under way relating to this subject, and the time will surely come when competent engineers can be secured for handling this particular part of the problem.

Mr. Lukens.—In reference to smoke, I would first call your attention to the Ordinance of Council, passed December 9, 1904.

Two men have been appointed at salaries of $1,200.00 per year. It is their duty to take observations and report violations to the office.

The offenders are informed of such violations and are notified to appear at the office and are instructed to make some provision for eliminating the smoke, and after being given sufficient notice and no provision has been made for the abatement of the smoke, legal action is then taken. The Bureau has found it necessary to take action in 104 cases and this has caused a considerable reduction in the smoke nuisance; but during the last anthracite coal strike, many manufacturers were compelled to lay in a considerable amount of the soft coal. Many of these were anthracite coal users and we have had considerable difficulty to have them return to the use of anthracite coal.

There have been installed in the city: 143 Murphy stokers; 96 Rooney stokers; 11 Jones underfed; 36 Taylor underfeed; 4 chain grates; 83 steam jets and automatic shaving feeds.

There has also been an abatement of smoke by 110 plants returning to the use of anthracite coal, thereby eliminating many complaints of the smoke. The complaints have not been confined to the stationary plants as the Bureau receives many complaints against the smoke from the railroads; and under the ordinance of Councils, ten (10) minutes are allowed for emitting smoke from locomotives when preparing fires, but does not specify in what time this 10 minutes smoke is allowed, which practically means a continuous smoke in the West Philadelphia Yards, where the fires of 300 locomotives are prepared daily, causing a considerable amount of smoke to be emitted. A large number of offenders are located along the railroads, and when they are compelled to make provision for abatement and comply with the law, they complain that they should be granted the same privilege as the railroads.

I believe if we could get the newspapers interested and public sentiment aroused, the smoke nuisance could be reduced to a minimum; and it is useless

to pass an ordinance making it a misdemeanor for one line of business to emit smoke and at the same time exempt some other form of business which may or may not be a greater nuisance.

Mr. Hartley.—This subject is not familiar to me just at present; in fact, I did not know what the subject announced for this evening was going to be until I arrived here, consequently I have given it no thought. However, it is a very important one in connection with the prevalent reform spirit now extending along sanitary lines of hygienic improvements. It is also of such scope as to exclude the possibility of thoroughly discussing in one evening the many means for eliminating the smoke nuisance.

Speaking from memory, I think we had this subject under discussion before, and about the time Mr. John M. Hartman was championing a bill before our City Councils—the object of which was for an Ordinance looking to compulsory means for abating, at least to some extent, the smoke nuisance. But unfortunately by the time the bill had got through that body it had been so mutilated as hardly to be recognizable, and what was left of it seemed to favor locomotives and all low stacks, as the Ordinance permitted the issuing of black smoke from stacks of a height covering that of locomotives; while for higher chimneys the color was restricted to a light gray.

To come to the principal cause of the existing smoke nuisance in this City, apart from the scientific principles therein, lies simply in the well known facts of the lack of boiler capacity in many of our manufacturing plants, owing to which necessitates heavy firing or the forcing through the furnaces of probably double the quantity of fuel that can possibly be perfectly consumed, in order to make up, as supposed, the power deficiency. In other words, should perfect combustion of say 15 pounds of soft coal be obtained per square foot of grate surface under natural draft, and giving off a minimum amount of smoke, the same result could not be expected if the amount of coal be increased, other conditions being the same, consequently a voluminous amount of smoke.

However, I notice a marked improvement in regard to smoke conditions over former years, due probably to more stringent measures and better knowledge in regard to firing of boilers and the general use of butiminous coal.

PAPER NO. 1117

THE DEVELOPMENT OF UNIT STRUCTURAL CONCRETE

Paper read before the Club

BY CHARLES D. WATSON

(Active Member)

Read October 19, 1912

While the Engineering Profession is somewhat familiar with the development in the construction of reinforced concrete buildings by what is known as the "Unit" method of erecting a building of previously moulded members, their acquaintance with the subject has been more or less through isolated and experimental developments, and few of them realize the scope of application and large amount of work in which these methods are now being employed.

It is not the object of this paper to enter into a long technical discussion of the merits of design of the unit method, which some of us believe to be based upon more rational and economical principles than commonly practiced, but rather to call attention to the extent of the development which we believe will some time culminate into standard practice for typical reinforced concrete building construction.

I think it is conceded by most engineers that our present common practices in reinforced concrete construction are crude and unscientific;—unscientific for the reason that we are compelled to use relatively large factors of safety owing to the unreliability of the quality of concrete which is made in the field and deposited in forms under the so-called "monolithic" system, and uneconomical on account of the enormous waste in materials for making forms.

The science of concrete construction is to a certain extent passing

through the same development through which iron and steel passed not so many years ago. Much credit for the present high development of this science is due to the manufacturers, who by perfecting processes, have given us a product which runs so uniform that factors of safety of three are common practice.

Under properly controlled conditions, it has been demonstrated that concrete can be made with an ultimate compressive strength averaging from five to six thousand pounds per square inch at sixty days of age, yet under our present practice in design it is quite uniformly conceded that six to seven hundred pounds is as high a limit as we are safe to take as the working stress. While this seems like an absurd factor of safety as compared with other structural materials, the development of the science has been fraught with too many accidents to warrant our taking higher working stresses.

I think it safe to say that the majority of failures in concrete construction are directly traceable to inferior concrete, and the greatest problem of the engineer is how to insure getting a material of proper quality, and strict adherence to design under present field methods of construction since unlike all other structural materials the members are moulded in place and cannot be previously tested or inspected until they become an integral part of the building, after which correction of defects is practically impossible.

With the constantly increasing price of lumber, the unsatisfactory results obtained by standard steel forms for monolithic construction, and the testimony of many of our largest contractors to the effect that the cost of temporary forms for structural concrete now averages from one-third to one-half of the total cost of the structure, it is evident that there is an opportunity for large economy in form expense.

These are the two primary incentives which have led to the development of the unit system of concrete construction under which the members are separately moulded either in a permanent or temporary factory, where practices can be standardized and conditions created to insure a uniformly high grade concrete, and the form expense reduced on account of its being possible to remove the forms much quicker than they can be in a monolithic structure, with the consequent reduction in the number of forms required and thus the cost.

return to a state of stable equilibrium. When the wind ceases the water which has accumulated on the lee shore falls below the mean level of the lake, while the water at the other end of the lake rises. Thus a series of rockings of the water of the whole lake takes place, the water at either end rising and falling alternately until a condition of rest is attained or until another wind starts the movement anew. This phenomenon is the same as may be observed in a basin of water where the water is disturbed slightly, moving from one side to the other before coming to rest. Other factors than the wind tend to produce these oscillations of water level, namely, differences in barometric pressure at the two ends of a lake, and differences of the temperature of the water. The wind, however, is by far the most impoıtant element in the problem.

In the Great Lakes the changes in level, due to the seiches, are often of considerable magnitude. They were carefully studied in Lake Erie by Professor A. J. Henry of the United States Weather Bureau in 1900 and described in Bulletin J of the Weather Bureau Publications. The fluctuations in the relative level in the water of the level at Buffalo at the easterly end, and at Amherstburg, Ont., at the west end of the lake, were recorded by automatic gauges. Diagrams given in the report show that the surface of this lake is almost never at rest, but constantly rocks back and forth, the average time of oscillation being between fourteen and fifteen hours. These changes in level frequently amount to several feet, and in extreme cases to ten or twelve feet or even more. Ordinarily, when the wind velocity is less than twenty-five miles per hour, the differences in level are not greater than one or two feet.

The storm of September 12, 1900, with a velocity of sixty-five miles an hour for two hours, caused the water level at Buffalo to rise about six feet above its previous level, while at Amherstburg the surface of the water fell about two feet. Soon after the wind fell below its highest velocity, the lake level began to fall and continued to fall for nine hours, the amplitude of the oscillation being 7′ 2″ and the time being a little less than sixteen hours. Professor Henry states that "the wind effect of this storm appears to have been much the same as would have been produced by a quick, powerful blow on the lake surface. The water of the whole lake was set in motion about a nodal line, and continued to rock for several days, the amplitude of each oscillation being a little less than that of the preceding one." Seiches of small amplitude occur

even when the weather is not stormy, and in most of the large lakes minor fluctuations occur, the level of the lake rising and falling a few inches every ten, twenty or thirty minutes, as the case may be.

During the summer when the lakes become thermally stratified with a stratum of cold and relatively heavy water at the bottom and warm lighter water at the top, the seiches produced by the wind in the upper strata gradually transfer their motion to the heavier water beneath, so that this also acquires an oscillatory motion, the amplitude and period of which may be different from that of the surface seiche. These variable fluctuations tend to mix the water of the two strata in the region of the thermocline.

The seiches have an important influence on the undertow currents described beyond.

Seiche movements may occur both longitudinally and transversely at the same time, in fact, this is probably the rule rather than the exception. The period of the transverse seiche is shorter than the other, so that along the shore in the middle of the lake the slopes of the water surface take various directions according to the manner in which the crests of the seiche movements coincide In consequence of this diagonal currents may be set up along the shore, which change frequently in force and direction, and which apparently bear but little relation to the direction of the wind blowing at the time. This is of particular importance in explaining the nature of the currents that occur after the wind which produced the seiche has ceased.

Vertical Currents

The water of the Great Lakes show, in general, the same fluctuations in the temperature of the water at the surface and at depths below the surface, as have been so frequently observed in smaller lakes and reservoirs. That is, during the summer the surface water is warmed by the sun, while the water at the depths is cold and quiescent. The wind stirs up the water of the lake and keeps it thoroughly mixed for a number of feet down from the surface. In small bodies of water the depth to which this wind action extends is seldom more than twenty or thirty feet, but in the large, deep lakes it is more. Observations made in Lake Erie at Cleveland, in 1904, showed that the lake water was stirred by the summer winds to a depth of about fifty feet, while observations made in

Lake Michigan in 1910 showed that the water was stirred to a depth of about sixty feet. Below the stratum within which circulation takes place, the temperature of the water changes rapidly and the region where this change occurs is known as the thermocline. Below the thermocline the bottom water in the middle of the lakes probably remains relatively quiescent for long periods, but for several miles out from the shore the lower strata move in and out and are seldom at rest.

The temperature of the water at the bottom of the Great Lakes during the period of summer stagnation is practically that of maximum density, i. e., 39.2° F. The author once measured the temperature at the bottom of Lake Champlain (396 feet) in June and found it to be 39.3°. Comparatively few observations of the temperature of the water at the bottom of the Great Lakes have been made, but they substantiate this statement. Recently observations in Lake Ontario near Rochester have shown that water of maximum density came within a mile and a half of the shore at a depth of forty feet.

During the winter the surface water is colder than the bottom water. The latter maintains its temperature at about maximum density throughout the year.

During the spring, as well as during the fall, there is a period when the water has an opportunity to circulate from top to bottom. In very large lakes this period is short, and whether circulation actually extends to the bottom is not known.

Besides the vertical circulation produced by the natural heating and cooling of the surface water and the action of the wind vertical circulation may also take place near the shore, due to the inflow of river water or sewage of a different temperature from the water of the lake. This sometimes has an important effect upon the manner in which these inflowing streams mix with the lake water.

Thermal stratification of the water in small lakes has an important effect upon the depth of the return currents above referred to, causing the back flow to take place above the layer of stagnant water. But in the Great Lakes the thermocline marks the dividing line between the upper and lower currents moving in opposite directions. It is an unstable thermocline and does not necessarily imply stagnation.

Local Wind Currents.

From the standpoint of the pollution of water supplies, the most important currents that take place in the lakes are the local currents produced by the movement of the wind from day to day. As the wind blows over the lake surface currents of the water are induced by it, and as the wind changes, these currents also change. Observations that have been made in Lake Erie, notably by Walter P. Rice, at Cleveland, in 1890, and by the Cleveland Water Department, in 1895, indicate that there is a fairly close relation between the wind movement and the movement of the surface water; the travel of the surface water being commonly from 4 to 6% of the wind movement and averaging about 5%. The movement of the water is less at depths below the surface, decreasing with the depth and presumably becoming zero at the neutral line, which recent studies in Lake Ontario have shown to be at mid-depth near the shore. Observations made in Owasco Lake, near Auburn, N. Y., in 1911, by Mr. J. Walter Ackerman and the author, showed that the percentage which the travel of the surface water was of the wind movement varied with the velocity of the wind, being 3.2% when the wind velocity was five miles per hour, but only 1.2% when the velocity was thirty miles per hour. These observations were, however, made in a lake of relatively small size.

The velocities induced by the wind are greater on the lee shore than on the weather shore.

In order to illustrate the effect of these local currents induced by the wind, let it be assumed that the wind has been blowing off shore for ten hours at the rate of twenty miles per hour in such a direction as to cause the water to flow from the sewer outfall towards the water supply intake, and let it be assumed further that the velocity of the surface water during this period was 3% of the wind movement. The surface water would, therefore, be carried six miles from the shore during the ten-hour period, a distance more than sufficient to carry it to the longest intake now in use.

In addition to the velocity of the surface water induced by the wind, it is important to know also the angle of dispersion. An attempt was made to measure this at Cleveland, in 1905. A group of floats was set adrift in Lake Erie, at a time when the wind was blowing at the rate of thirteen miles per hour, and the position of each float observed for several hours. In one experiment after the floats had traveled 2,500 feet, which was 4.7% of the wind move-

ment, they had spread through an angle of about 5°. In other experiments with higher wind velocities, the angle of dispersion was slightly less. At the present time no data exist showing the relation between wind velocity and the angle of dispersion. It varies widely according to the veering of the wind and may be as high as 30° or 60° more. After several days of variable winds the fan of polluted water may spread over a semi-circle.

Undertow Currents.

When the wind blows strongly towards a lee shore the raised water level that results causes an outward current of the water beneath the surface. This phenomenon has long been familiar to fishermen and bathers. It has not been fully realized, however, that the undertow currents sometimes extend for several miles into the lake and well beyond the ordinary water supply intakes. As a result shore water is carried outward and sewage contaminated water periodically enters the intake, and is pumped into the city mains. The best evidence of these undertow currents is obtained by a study of the temperature of the water at different depths, at different distances from the shore and of the temperature of the water drawn from the intakes.

Daily observations of the temperature of the water at Milwaukee and elsewhere during the summer have shown very great changes in the course of a few days. Thus at Milwaukee, the temperature of the water at the pumping was 68° on July 20, 1910; on July 23, it was 62°; and on July 27th, 52°. At Rochester, even more sudden changes have been noticed. For example, on August 8, 1912, the temperature of the water at the bottom of the lake at a point 6,000 feet from the shore, where the depth was forty feet, the temperature fell from 59° to 42° in eight hours, the surface temperature meanwhile remaining about 64°. Two days previous, at the same distance from the shore, the temperature of the water had been 63° at all depths. The drop in temperature followed a sudden change in the direction of the wind from on-shore to off-shore.

The data now at hand indicate that the dividing line between the incoming and outgoing water lies at about mid depth.

When the warm surface water is blown away from the shore and cold water flows landward near the bottom, not all of the bottom water flows in as far as the shore line. Some of it becomes mixed with the upper strata and returns to the lake before it reaches the

shore line. The extent to which this off-shore mixing takes place has not yet been determined by adequate studies.

The undertow currents are of great importance in connection with the dispersion of sewage. During the summer season the temperature of the sewage will be ordinarily not far from that of the surface water of the lakes. If the sewage is discharged at the bottom of a lake at a considerable distance from the shore, it is obvious that when the cold, deep water is flowing shoreward, the sewage will be warmer and lighter than the water into which it is discharged. The sewage will, therefore, tend to rise into the upper strata and be carried away from the shore by the outward surface current. When the warm shore water is going out at the bottom the sewage will enter water of approximately its own temperature and will have less tendency to rise and will be carried away from the shore by the outward bottom current. Thus during the summer the movements of the wind, whether towards or away from the shore, tend at most times to carry the sewage away from the shore rather than towards it.

Effect of Breakwaters.

When sewage is discharged back of a breakwater or a natural bar off the shore, the water back of it is protected from the undertow currents. An on-shore wind causes the sewage to be held back of the breakwater, while the lake water blown towards the shore turns at the obstruction and flows downward and outward. On the cessation of the wind, or its change to the opposite direction, the over-polluted water back of the breakwater flows out as a surface current and thus gives use to streaks of polluted water that may extend far into the lake.

A somewhat similar phenomenon is when streams discharge into a lake through wide channels of low slope. In these there is a similar checking of the current followed by a subsequent increased discharge.

Lake Pollution.

The principal sources of pollution of the lake water supplies are, first, sewage discharged directly into the lake along the water front. Second, sewage discharged into streams that flow into the lake. Third, sewage polluted mud dredged from rivers and harbors and dumped into the lake. Fourth, sewage sludge transported by ice from the shore outward. Fifth, fecal matter discharged into the lake from boats.

The danger of pollution of the water supply in any case depends upon the opportunities afforded for the commingling of the sewage with the water before it reaches the intake, and upon the natural purification that takes place in the lake.

Dispersion of Sewage in Lake Waters.

When sewage is discharged into a lake it mingles with the water and gradually becomes dispersed through it, the nature and extent of the dispersion being dependent upon the local currents induced by the wind. It is impossible to calculate exactly the dilution of the sewage at different distances from the sources of pollution, for there are too many unknown factors, but computations based on arbitrary assumptions are sometimes found useful in showing approximately the dilution that may be expected under different conditions.

For example, suppose that sewage is being discharged at a point off shore and is dispersed through a sector that has an angle θ; and suppose, for purposes of calculation, that the sewage mixes through the entire depth and that this depth is constant. Let Q stand for the quantity of sewage discharged in time t, let r = the distance traveled by the water, under the influence of the wind in the same time, i. e. let r be the radius of the sector; and let d be the depth. If D represents the dilution, then

After time t $$D_t = \frac{\pi r^2 d.}{Q} \quad \frac{\theta}{360}$$

After time 2 t $$D = \frac{3 \pi r^2 d}{Q} \quad \frac{\theta}{360}$$

After time nt $$D_{nt} = \frac{(2n-1) \pi r^2 d}{Q} \quad \frac{\theta}{360}$$

To apply this to a practical case, suppose that sewage is being discharged at the rate of 25 million gallons per day; that the depth of water is fifty feet; that the wind movement is 100 miles per day and the water travel 5% of this, or five miles per day; that the angle of dispersion is 5°; and that t is one minute. Then Q = 2320 cubic feet per minute and r = 18.3 feet per minute.

$$D_{nt} \cdot \quad \frac{(2m-1)x3.1416x18.3^2x50}{2320} \quad \frac{5}{360} = .315 \ (2N-1)$$

Suppose that the sewage contains 1,000,000 bacteria per cc. and the

water none. Then for different distances from the point of discharge the water would contain the following numbers of bacteria:

R	N	D	Bacteria Per cc.
100 feet	5.46	3.13	320,000
500 "	27.3	16.80	59,600
1000 "	54.6	34.1	29,300
2000 "	109.2	68.4	14,600
3000 "	163.8	103.0	9,700
4000 "	218.4	137.2	7,300
5000 "	273.0	171.5	5,900
6000 "	327.6	203.0	4,900
7000 "	382.2	241.0	4,200
10000 "	546.0	344.0	2,900
15000 "	819.0	516.0	1,900
20000 "	1092.0	669.0	1,500

For different angles of dispersion the following numbers of bacteria would be found at different distances from the point of discharge:

Distance From Point of Discharge in Feet.	Number of Bacteria Per cc.			
	5°	10°	30°	60°
100	320,000	160,000	53,000	27,000
500	59,600	29,800	10,000	5,000
1,000	29,300	14,700	4,900	2,900
2,000	14,600	7,300	2,400	1,200
3,000	9,700	4,800	1,600	800
4,000	7,300	3,700	1,200	600
5,000	5,900	3,000	1,000	500
10,000	2,900	1,500	480	240
15,000	1,900	950	320	160
20,000	1,500	750	250	125

Natural Agencies of Purification in Lake Waters.

In addition to the very great and rapid dispersion of sewage in the water of the Great Lakes, various other agencies tend to bring about its natural purification.

Sedimentation is a potent factor. Compared with streams the velocities of the water in the lakes are low, so that, except near the shore, the suspended matter settles to the bottom, leaving the upper

broad waters of the lake very clear. Sedimentation must always be considered, however, with reference to subsequent disturbances of the settled solids by currents. During long periods of quiescence, pathogenic bacteria are liable to natural death in an unfavorable environment.

According to the best available information, the germs of typhoid fever do not multiply in the waters of the lake, but rather disappear at rates that vary according to different conditions. Using approximate figures for the sake of illustration it may be said that after a week ninety per cent. of any typhoid fever germs that may enter one of the lakes will have died, and after a month, ninety-nine per cent. How long the most resistant germs can survive is quite unknown. A small number, sometimes termed the "resistant minority," doubtless remain alive for several months. They are able to live longer in cold water than in warm water, a fact that Houston has recently demonstrated by some interesting experiments.

Sunlight exerts a powerful germicidal action on the bacteria in the layers of water near the surface, but even in the waters of a clear lake the sun's rays rapidly lose their energy below the surface so that disinfection by sunlight is not a factor at depths greater than a few feet.

Very important, however, is the action of the microscopic organisms found in the waters of all the lakes and that comprise the "plankton." The biological cycle is wondrously complete. Particles of sewage solids are decomposed by bacteria; bacteria are consumed by the protozoa; protozoa are consumed by rotifers and crustacea and the latter are eaten by fish. Also the products of bacterial action on the dispersed sewage, such as nitrates and carbonic acid, furnish food for the algae, such as floating diatoms and various chlorophyceae, and these in turn furnish food for the crustacea and larger organisms.

The oxygen resources in the Great Lakes are so enormous that except very near to the sources of pollution the lake water is saturated with dissolved oxygen. The complete destruction of the organic matter of the sewage by oxidation is, therefore, the ultimate fate of all sewage matters that enter the lakes.

Observed Contamination of Lake Water by Sewage.

Systematic analyses of the lake water in the vicinity of

Milwaukee, Chicago, Cleveland, Toronto and Rochester have given results not inconsistent with computation similar to the preceding. In general, they have shown that the dilution of sewage discharged into the lakes is ordinarily very great. It is, however, very variable and under certain conditions that occur several times each year, the sewage is projected through the lake water for several miles with relatively little dilution. When the path of this sewage stream lies in a direction from the sewer outfall to the water works intake, contamination of the water supply may and does occur.

The analyses that have proved most serviceable in the study of this problem are the following: (1) Number bacteria per cc. (2) Test for B. coli. (3) Turbidity. (4) Odor. (5) Chlorine.

The relative sensitiveness of these determinations varies according to the nature of the sewage. Ordinarily, the bacterial tests are the most sensitive, but not infrequently the simple odor test is equally satisfactory.

As an illustration of the observed contamination of lake water by sewage, mention may be here made of the studies conducted by the Milwaukee Sewerage Commission during the summer of 1910.

The sewage of Milwaukee, which then amounted to about 60 million gallons per day, is practically all discharged into the lake at the mouth of the Milwaukee River. Thence it spreads outward through the lake water and covers a fan-shaped area, becoming diluted as it leaves the shore. The water at the mouth of the river was found to contain very large numbers of bacteria, the average being 1,268,000 per cc., the minimum 525,000, and the maximum 2,600,000 per cc. The following figures show the observed numbers of bacteria at different distances from the shore along a line extending outward into the lake from the river mouth.

Average Number of Bacteria in Lake Michigan Water at Different Distances from the Shore Opposite the Mouth of the Milwaukee River

Location.	Bacteria Per c,c.
Mouth of River	1,268,000
1 Mile East of River Mouth	207,000
2 Miles " " " "	2,000
3 " " " " "	970
4 " " " "	225
5 " " " " "	45

The water supply intake is about 3.5 miles in a straight line northeast of the river mouth. Here the average number of bacteria was 1,182 per cc. at the surface and 693 per cc. at the bottom, the largest numbers being 3,720 at the surface and 1,600 at the bottom, and the smallest numbers being twenty at the surface and fifty at the bottom. Generally speaking, the bacteria were higher at the surface than at the bottom, but sometimes the opposite was the case.

The observations of the Commission covered samples of water collected at intervals of one mile along a series of lines one mile apart from the shore outwards for three or four miles. Several series of samples were collected with the wind blowing in different directions. The results showed what would be naturally expected that the greatest amount of pollution could be traced in the direction towards which the wind was blowing. At times the axis of greatest pollution extended in a northeasterly direction towards and beyond the intake. At other times the course of the sewage was southerly.

Tests for B. coli were made on all of the samples of water collected, and estimates made of the average number present at each station. Thus at the mouth of the river the estimated average number of B. coli was 847 per cc. The numbers decreased outward from the shore, until at a point five miles from the shore the water contained less than one B. coli per cc. At the intake of the water works, the number was 2.1 per cc. at the surface and 0.4 per cc.at the bottom.

A study of the B. coli tests showed in a striking way the effect of the on-shore winds in causing the polluted water to pass out into the lake at the bottom and the effect of the off-shore winds in causing it to spread out over the surface. Thus, taking all of the samples collected at points more than a mile away from the shore, it was found that when the wind was blowing towards the shore the bottom water contained four times as many B. coli as the surface water, but that when the wind was blowing off shore the surface water contained eight times as many B. coli as the bottom water.

The effect of the sewage of the city on the bacterial character of the water at the intake and the variations from day to day are shown by the following daily analyses:

Daily Analysis of Water at the North Point Pumping Station

Date 1910	Hour P. M.	Temperature Fahr.	Turbidity	Color	Odor[1]	Chlorine	Bacteria per cc	Test for B. Coli 0.1 cc	1.0 cc	10. cc
Sep. 21	4:50	57.8	2	2	1v	4.0	2000	0	+	+
22	3:55	58.0	2	3	1v	4.2	1500	0	+	+
23	4:05	58.3	6	9	2v	4.0	1270	+	+	+
24	4:10	58.1	14	4	1v	4.5	1310	+	+	+
25	5:00	57.9	6	2	1v	4.2	1270	+	+	+
26	4:45	58.0	12	7	3d	4.2	1940	+	+	+
27	3:55	57.9	4	2	2m	4.0	2065	+	+	+
28	2:50	57.8	7	4	2v	4.0	1820	+	+	+
29	4:25	57.8	4	3	1v	4.0	1750	+	+	+
30	4:10	57.0	..	..	..	...	1100	0	0	+
Oct. 1	4:20	57.1	5	4	1v	4.2	3000	+	+	+
2	...	....	..	..	..	...	....	...	...	...
3	4:00	53.2	6	2	1v	4.0	2300	+	+	+
4	3:30	52.5	6	3	1v	4.8	940	+	+	+
5	1:58	47.0	4	4	1v	4.2	1250	+	+	+
6	3:50	56.5	10	4	2m	...	3500	0	+	+
7	4:40	56.0	7	2	2v	4.0	825	0	+	+
8	4:00	53.7	6	2	1v	4.2	1315	0	+	+
10	4:30	55.3	5	2	1v	4.2	1250	+	+	+
11	2:10	46.4	6	2	1v	4.0	500	0	+	+
12	3:40	53.4	20	4	1v	4.0	900	0	+	+
13	11:35*	54.3	15	4	1v	4.0	870	0	+	+
14	3:00	53.5	10	3	1v	4.0	345	0	+	+
15	5:20	54.8	4	2	1v	4.5	330	0	+	+
17	2:40	54.9	5	5	1v	4.0	5900	+	+	+
18	4:45	54.7	3	3	2v	4.2	800	0	+	+
19	12:05	54.1	6	3	1v	4.2	1200	0	+	+
20	4:20	54.5	15	4	2m	4.0	1215	0	+	+
21	3:55	54.0	10	3	2v	4.0	680	0	0	+
22	3:45	53.3	20	5	2v	4.0	1950	0	+	+
24	2:25	53.0	8	3	1v	4.0	2750	+	+	+
25	3:35	53.3	12	2	1m	4.5	1025	0	+	+

[1] 1v—very faint vegetable; 2v—faint vegetable; 2m—faint moldy; 3d—distinct, disagreeable.

Contaminated Lake Water Supplies and the Public Health.

Stronger proof than that furnished by analysis is the effect of the use of contaminated water on the public health measured by vital statistics. A very complete study of the death-rates from typhoid fever and other diarrhoeal diseases in the cities that take

* A. M.

their water supplies from the Great Lakes has been recently published by Dr. Allan J. McLaughlin, in the form of two bulletins (Nos. 77 and 83 of the Hygienic Laboratory of the Public Health and Marine Hospital Service of the United States) entitled "Sewage Pollution of Interstate and International Waters with Special Reference to the Spread of Typhoid Fever." These reports describe the water supply and sewerage conditions in each of the lake cities and give tables of vital statistics compiled from local sources and from data gathered by the United States Census Bureau. The statistics are illustrated by many diagrams.

The case made out against the lake cities that do not filter their water supplies is a strong one. The typhoid fever death rates are shown to be very high as compared with European cities and with the cities of the United States that have safe water supplies. As an illustration of these high rates, the following table, compiled from the United States Census reports, is here presented:

TYHHOID FEVER DEATH RATES OF CERTAIN CITIES SUPPLIED WITH WATER FROM THE GREAT LAKES

(Data from United States Census Reports)

City.	Population 1910 Census.	Typhoid Fever Death Rate per 100,000									
		1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
LAKE SUPERIOR											
Duluth, Minn.	78,466	74.1	53.7	64.8	54.4	44.7	46.0	41.6	56.8	52.3	75.9
Marquette, Mich.	11,503	19.6	57.9	28.5	37.5	37.0	36.5	71.9	44.4	52.5	95.3
LAKE MICHIGAN											
Chicago, Ill.	2,185,283	29.8	45.1	32.1	20.1	16.5	18.3	17.7	15.3	12.6	14.7
Milwaukee, Wis.	373,857	22.1	15.1	16.8	13.6	22.7	30.5	25.7	17.4	21.2	45.7
Muskegon, Mich.	24,062	19.2	14.4	19.2	28.7	28.7	33.4	14.3	33.4	.....	24.8
Michigan City, Ind.	19,027	13.1	31.9	68.4	54.6	35.5	34.7	50.8	48.9	27.0	47.1
Marinette, Wis.	14,610	31.2	31.5	51.0	25.8	39.1	26.3	40.0	13.5	25.0	48.0
Escanaba, Mich.	13,194	50.3	67.8	28.0	351.4	182.8	101.1	120.2	126.5	230.0	60.3
Traverse City, Mich.	12,115	30.4	19.4	.....	35.6	25.7	90.5	23.8	53.6	29.6	24.7
Menominee, Mich.	10,506	56.5	25.1	86.8	117.2	46.9	78.2	91.8	64.0	54.5	66.7
LAKE HURON											
Bay City, Mich.	45,166	25.3	36.2	54.3	43.4	24.6	49.3	41.9	49.3	35.9	24.3
Port Huron, Mich.	18,863	41.3	61.2	25.2	34.9	14.8	53.8	43.5	19.1	52.1	74.4
Sault Ste. Marie, Mich.	12,615	92.9	172.9	115.9	52.4	68.6	58.9	16.5	72.9	56.1	23.7
LAKE ERIE											
Cleveland, Ohio	560,663	34.9	35.5	115.0	49.6	14.9	20.2	18.9	12.6	13.4	17.9
Buffalo, N. Y.	423,715	27.1	33.7	34.6	24.2	24.4	23.6	29.2	20.7	23.8	20.2
Detroit, Mich.	465,766	20.1	23.5	20.0	17.6	21.2	22.3	28.3	22.3	20.5	23.0
Erie, Penn.	66,525	16.7	25.4	33.7	48.6	17.0	48.3	78.4	62.5	29.0	38.9
Astabula, Ohio	18,266	44.9	36.3	49.4	137.1	60.0	38.9	19.0	86.2	42.0	43.6
Dunkirk, N. Y.	17,221	24.3	76.6	50.9	41.4	46.1	37.7	72.2	11.5	5.9	23.1
LAKE ONTARIO											
Toronto, Ont.	208,040*	17.8	14.3	18.2	25.8	18.7	31.4	.....	.....	.....	....
Niagara Falls, N. Y.	30,445	143.9	130.4	126.9	139.8	181.6	147.3	126.6	98.0	87.5	98.0
Kingston, Ont.	17,691*	39.0	5.5	99.5	22.1	38.5	38.4	.....	23.1	34.8	23.1

*Census of 1901.

Dr. McLaughlin points out that in the lake cities that use unfiltered water the typhoid fever death rate is exceptionally high during the winter season, thus affording additional evidence that this disease is more often transmitted by cold water than by warm water. He also shows that intestinal diseases classed as diarrhoea and enteritis, and infantile diseases are exceptionally prevalent in the lake cities that use unfiltered water and they too are liable to occur in the winter under the name "winter cholera."

In view of the completeness and accessibility of his reports, it is unnecessary to discuss this subject in detail.

Water Supply Intakes.

The lakes are the natural sources of water supply of the cities and towns near them, and in some instances they are the only possible sources. The land around the lakes is generally flat and no upland gravity supplies are obtainable. A few places, like Toledo, are supplied with water pumped from streams entering the lakes, but in most instances water of better quality and of unlimited volume is found in the lakes themselves. The fact that the supply is unlimited, or rather is limited only by the capacity of the pumps installed, seems to have encouraged a lavish use and waste of water, for we find that the per capita consumption of water in the lake cities has been high. The fact that the water is relatively cool in summer has, in some cases, developed a unique use of the water supply for cooling purposes. In recent years a number of unsuccessful attempts have been made to cut down the consumption.

The broad waters of the lake cannot be used for water supplies as it is not practicable to extend intake pipes or tunnels to points where the depth of water much exceeds 75 feet. The longest intake in use is that at Cleveland, which is 26,000 feet long and the end of which is about four miles from the shore. The Chicago intakes are from two to four miles long. The intakes at Milwaukee, Gary and Oswego are about a mile and a half long. There are several intakes about a mile long, namely, those at Bay City, Ashland, Kanawha, Sheboygan, Evanstown, Racine and Erie. Many of the intakes are shorter than this extending from 1,000 to 3,000 feet from the shore, and in some cases they are less than 1,000 feet.

Comparatively few intakes are located in water more than 50 feet deep. One of the deepest is that at Duluth, where the water is 75 feet deep and the openings in the crib 60 feet below the sur-

face of the water. The Toronto intake extends into water 68 feet deep, and it is proposed to extend it to water 100 feet deep. Oswego is constructing an intake in 83 feet of water. The Milwaukee intake is in 60 feet of water and the Chicago intakes are in from 27 to 40 feet of water.

The attempt seems to have been made in every case to extend the intake far enough to obtain relatively clear water and avoid pollution of the intake from local sewers. How inadequately the latter has been accomplished is shown by the typhoid fever statistics elsewhere quoted. Other considerations have been to have the intake in water deep enough to avoid a packing of the ice around the crib in the winter and to avoid the silting and clogging of the intake and pipe through movements of the sand. It has ordinarily been found desirable to have a depth of 20 or 30 feet.

The intakes at Cleveland and Chicago terminate in masonry cribs that extend above the water and are surmounted by light-houses. These cribs have entry ports at different depths. More often the intake pipes terminate in a submerged crib, or the pipe is merely turned up and supported by loose rock. Cast iron pipe has been largely used in the past, but steel is gradually taking its place. Tunnels are used at Chicago, Cleveland and elsewhere.

Many breaks have occurred in the lake intakes and a recital of the accidents would be interesting. In several notable instances, as at Toronto, these accidents have permitted polluted shore water to enter the pipes and outbreaks of disease have followed.

Methods of Protecting Lake Water Supplies.

The evidence is conclusive that natural methods of purification cannot be depended upon to protect the sanitary quality of the water supplies taken from the Great Lakes. Practically every city, whether great or small, that has depended solely upon the protection afforded by dilution and a supposedly remote location of the intake from the sewers has suffered from water borne diseases. As a rule, the smaller cities have suffered more than the large cities as their water supply intakes and sewer outfalls are nearer together. The visitations of typhoid fever have often been intermittent, and their failure to occur at regular seasons engenders a false sense of security; but sooner or later, when the necessary combination of currents and infection occurs, every lake city that fails to protect its water supply is bound to suffer from water-borne diseases.

Various expedients have been used at different times and at different places. At Chicago, after it became certain that its water supplies were subject to sewage pollution in different degrees according to the weather conditions the Health Department of the city inaugurated the policy of making daily analyses and issuing notices of the condition of the water in the daily papers, warning the people to boil the water or to cease using it for drinking in case the analysis was bad. This was many years ago. The practice may have had some beneficial effect, but it was placing dependence upon a frail reed. It had the inherent disadvantage that the quality of the water changed more rapidly than the analyses could be made and published.

A second method of protection would be to abandon the lake water altogether and substitute some other source of supply. This has been considered in some cities, as for example, at Toronto, where a gravity supply has been considered and rejected. Most of the lake cities are so situated that another source of supply is impracticable, or, in any event, costly, so this course has not been adopted and is not likely to be.

A third method is to extend the intake further into the lake. This has been done repeatedly. As the cities have grown the local pollution has become heavier and larger intakes have been required on account of greater water consumption. The effect of using longer intakes farther removed from sources of pollution has invariably improved the condition of the water, sometimes very noticeably. After a time, the water at the new intakes becomes contaminated so that the remedy is merely of temporary benefit. Then too, there is a limit to which this can be carried as the water off shore becomes too deep for economical pipe laying.

A fourth method would be to keep the sewage out of the lake. This is practically impossible, as the natural drainage of the lake cities is towards the shore. Ordinarily, no attempt has been made to keep the sewage out.

Chicago presents the only important instance where it has been accomplished and here it has not been accomplished in full. Situated at the south end of Lake Michigan and with only a low divide between it and the streams that flow westerly into the Mississippi River basin, and with this divide near at hand, it was possible to cut a canal through the divide, and turn the flow of the principal sewers into it, so that the sewage would flow westerly. This pro-

ject, known as the Chicago Drainage Canal, cost upwards of forty million dollars and entails a considerable annual charge for maintenance. A city of small size could not have financed so great an undertaking. The canal is so arranged that the Chicago River and its branches now discharge into it instead of into Lake Michigan; the lake water flows in at the old river mouth and dilutes the sewage, also turned from the lake into the river. The canal extends to Lockport, where the diluted sewage is discharged into the Des Plaines River, which flows into the Illinois River, this in turn flowing into the Mississippi River. The use of this canal lead to a notable suit in the United States Supreme Court, brought by the State of Missouri, acting in the interest of St. Louis, against the State of Illinois and the Chicago Drainage Canal District, which was settled in favor of Chicago.

This canal receives most, but not all, of the sewage of the city. In the southern part of the city there are large sewers that still discharge into the lake and pollute its waters. Projects are now in contemplation that will divert much of this sewage westward into the canal. It is recognized, however, that this method of diversion and dilution has a limit and that this limit will be exceeded before many years, so that projects are also being considered for the treatment of the sewage before it is discharged into the canal.

The Chicago Drainage Canal has very materially reduced the amount of typhoid fever in the city. It has not entirely prevented all pollution of the water supply. The large storm flows of the sewers still go into the lake and at certain times this may affect the water supplies from the various cribs. Furthermore, the accidental contamination of the lake water from so large a city with its shipping, its dredging operations, its industries located along the shore, is by no means a negligible factor. To protect the lake water against all these is a difficult task, except by filtration.

Protection by Sewage Treatment.

The next method of protection to be considered is the purification of the sewage before it is discharged into the lake. This has long received the attention of engineers and so much has been said about it in popular writings that the public has come to have faith in it. It is a plausible idea, and theoretically sound, but it has one fatal defect. To accomplish the purification of all of the sewage at all times demands works of excessive cost, while to partially

purify the sewage, or to fail to purify it at times of storm does not give the desired protection to the water supply. Nearly all large cities are sewered on the combined system, that is, the same pipes and conduits carry both house sewage and storm water. Purification works large enough for the treatment of all the storm water, as well as the house sewage, are almost never constructed, but overflows are provided to take the excess sewage at times of heavy rain. This storm overflow is merely the house sewage diluted and from a sanitary standpoint is dangerous. The storms that produce the overflow are likely to be accompanied by strong winds that create rapid and direct currents of the water in the lake, so that the method of protection by sewage treatment fails at those times when it is most needed.

The term "sewage purification" has been frequently used to cover methods of sewage treatment that only partially purify and that do not yield satisfactory effluents, considered from a sanitary standpoint. For example, it has been applied to screening, to sedimentation, to septic tanks, to chemical precipitation, to the use of contact beds, etc., processes which are often of great merit in their proper field, but which do not by any means convert sewage into drinking water, or into a liquid that can be safely mixed with drinking water. The misuse of the term "sewage purification" has thus led laymen to the belief that a lake water could be protected simply by "purifying" the sewage. The more recent use of the term "sewage treatment" instead of "sewage purification" should help to disabuse the mind of the public in this regard.

Treatment of the sewage of lake cities is often desirable in order to prevent objectionable conditions in the lake water near the point of discharge, and some form of treatment is likely to be adopted by nearly all of them. The nature of the treatment required will be usually governed by conditions other than the protection of the water supply. These treatments will, at the same time, somewhat reduce the danger of the pollution of the water supplies and will serve as an additional factor of safety. The point here emphasized is that in themselves, they are not sufficient to protect the water supplies.

The disinfection of the sewage by the use of chloride of lime has been suggested and if this could be carried out thoroughly the safety of the sewage effluent would be materially enhanced. The cost of disinfecting sewage, however, would be much greater than

the cost of disinfecting the water supply, so that, if disinfection were to be depended upon, the latter would naturally be preferred. The difficulty of disinfecting the overflow sewage at times of storm is another very great objection to this method. Used in connection with other forms of sewage treatment disinfection would further increase the factor of safety, but it ought not to be depended upon alone to protect the lake water supplies.

Disinfection of Lake Water.

If nature's methods of purification cannot be depended upon, if in the present state of the art an adequate purification of all the sewage is impossible of attainment, and if a partial treatment of the sewage does not suffice, the only course left is to purify the water supply itself. Fortunately this can be done satisfactorily and at reasonable cost. There are two methods of purification available for lake waters at the present time—disinfection and filtration.

The disinfection of the lake water supplies has been extensively practiced during the last few years. Among the larger cities where it has been used may be mentioned Toronto, Milwaukee, Cleveland, Erie and Niagara Falls. Chloride of lime, or bleaching, has been chiefly used, but at Cleveland liquid chlorine was tried with success.

The fact that the lake waters contain relatively small amounts of organic matter as compared with other surface waters enables disinfection to be accomplished by the use of small quantities of chemicals. For the same reason, the use of an excess of chemicals is readily noticed by the consumers on account of the disagreeable odor of chloride of lime that persists until the water reaches the service taps. Great caution is, therefore, required in the use of this method. If too little bleaching powder solution is added the disinfection will not be effective, while if too much is added the water will have a bad odor. The quantities of bleaching powder used have varied from six to eighteen pounds per million gallons. (10 pounds of calcium hypochlorite, containing 35% of available chlorine, per million gallons of water is equivalent to 0.42 parts per million of available chlorine.) Generally, the smallest quantity found necessary to give effective sterilization of the water has been six to eight pounds per million gallons. Quantities larger than about ten pounds commonly leave undecomposed hypochlorites in the water that may be detected by the consumers.

It is of the greatest importance to secure a prompt and intimate mixture of the bleaching powder solution with the water. This is not as easily accomplished as many think and requires a degree of skill in operation not easily obtained in practice. Failure to properly apply the chemical may easily escape knowledge of the authorities and such failure may be calamitous in its results.

That effective sterilization of the water can be obtained by this method is admitted by sanitarians; that it actually is obtained with practice is more doubtful. As an illustration of its results in a scientifically controlled plant the experience of Erie may be cited.

After the severe epidemic of typhoid fever that occurred in Erie during the first four months of 1911, a disinfecting plant was installed. During the first few weeks of operation, namely, from March 15 to April 25, the numbers of bacteria in the treated water did not exceed 50 per cc. and averaged only 7 per cc. During this period, from seven to ten pounds of bleaching powder per million gallons of water were used. Later, this was reduced to six to eight pounds. The average numbers of bacteria per cc. in the raw and treated waters during subsequent months were as follows: No. B. coli were found in the treated water.

Month.	Bacteria Per cc.	
	Raw Water.	Treated Water.
March, 1911	200	5
April, "	225	10
May, "	495	160
June, "	505	165
July, "	165	35
August, "	295	50
September, "	215	35
October, "	380	35
November, "	500	45
December, "	400	35

That the use of bleaching powder as a water disinfectant has reduced the typhoid fever death-rates in many places is probable, but its use has not been continued long enough to enable this to be measured with great certainty. That it does not completely protect against water-borne diseases is also probable. Thus, at Toronto, the water supply was disinfected before the recently con-

structed filter was put into use. During this period, it is said that the typhoid fever death-rate fell considerably below what it had been when untreated water was supplied, but after the filter was put into operation there was a further reduction of the death-rate, showing that disinfection alone had not furnished complete protection.

The method of disinfection of lake supplies ought to be looked upon not as a means of permanent protection of the quality of the water, but rather as a temporary or emergency measure. The uncertainties of operation are too great, the chances that not all bacteria are killed are too large to make this method one to be depended upon solely and permanently. And it is doubtful if the consumers will be long satisfied with water that may at any moment run from the service taps with an odor of chloride of lime. In the case of supplies that are only slightly contaminated it may be used to reduce still further the chance of infection, and thus, perhaps, postpone the time when filters are required, but such instances are few.

Filtration of Lake Water.

The best method of protecting the lake water supplies is to filter the water. This is more efficient than disinfection of the water and is very much cheaper than purification of the sewage.

Disinfection of the water does not remove any turbidity that may be present; filtration does. Disinfection does not remove any odor that may be present, due to algae; filtration, with aeration, does this, and while it is not often a matter of great moment, at times it may be of decided benefit. Therefore, although filtration costs more than disinfection, it gives more effective service and is more dependable.

Two methods of filtration are in use in the lake cities, sand filtration and mechanical filtration. These are now so well known that they do not need to be described. Suffice it to say that sand filters are operated at relatively low rates, say from two to six million gallons per day, and that mechanical filters employ a rate of about 125 million gallons per day. Sulphate of alumina, or some other coagulant, is employed with mechanical filters.

The choice of the two systems should be determined for each case according to the character of the water to be filtered, the availability of filter sites at proper elevation, and other local conditions. Generally speaking, sand filters are especially applicable to relatively

clear waters and mechanical filters to waters that are turbid for a considerable portion of the time. In general practice has followed this classification. Mechanical filters have been used by a number of the cities on the south shore of Lake Erie, as for example, Lorain, Elyria, Vermillion, Sandusky, Conneaut and Ashtabula. Here the intakes are rather near the shore and the water is somewhat turbid. A mechanical filter is now being designed for Evanston for the same reason, namely, that the shore water is turbid. At Toronto, on the other hand, where the turbidity is seldom high, a sand filter has been recently constructed and is now in operation. In a few instances, mechanical filters have been installed to purify relatively clear lake waters, namely, at Niagara Falls, on the Niagara River, and at Burlington, Vt., on Lake Champlain. Such filters are at a disadvantage from the standpoint of operation in that the attendant cannot as readily tell how the filter is working, for the reason that there is little difference in the appearance of the water before and after filtration. In the case of turbid or colored water, this difference is conspicuous, and failure to obtain perfect clarification is an indication of poor efficiency. Mechanical filters with clear waters have not been operated long enough to enable one to fairly judge of their success. It has been found that the quantity of alum necessary to be used with a mechanical filter operating on a clear water cannot be reduced much below ¾ grain per gallon without impairing the bacterial efficiency.

With clear lake waters the rate of sand filtration may be higher than in the case of other surface waters. The Toronto filter, for example, was designed for a rate of 6,000,000 gallons per acre per day, and when operated at this rate satisfactory bacterial efficiencies have been obtained.

Although sand filters cost somewhat more to construct than mechanical filters, this difference is not great and their cost of operation is less, so that when interest charges, operation and depreciation are all taken into account, the cost of the sand filtration may be less than that of mechanical filtration, while on the whole, the results are more dependable as less skill is required in operation. Good results, however, can be obtained by either method. Both mechanical filters and sand filters need to be faithfully operated and enlarged when necessary, in order that their capacity may not be overtaxed. Failure to do so may involve serious trouble. For example, the sand filter at Ashland, Wis. is said to have been over-

taxed to such an extent that filtration became imperfect and typhoid fever increased in the city. At Lorain, Ohio, faulty operation of the mechanical filter likewise caused an increase of typhoid fever in 1903.

In order to furnish an additional safeguard against infection of the water, it is becoming customary to provide for the disinfection of the water after filtration so that if for any reason the process of filtration has to be suspended, or if the bacterial efficiency falls below what it should be, hypochlorite may be used.

With the water supply filtered, expensive treatment of the sewage discharged into the lake is usually unnecessary. In fact, in some cases no purification may be required so far as the protection of the water supply is concerned. Treatment of the sewage, of course, gives an additional factor of safety.

The Problem a Local One.

The problem of protecting the water supplies of the lake cities is primarily and distinctly a local one. Each city is guilty of polluting its own water supply and each city is innocent of polluting the water supplies of its neighbors. There are perhaps a few minor exceptions and these are chiefly on the streams connecting the lakes. For example, the water supply of Detroit is somewhat polluted by the sewage of other places on the Detroit River, and the water supply of Niagara Falls is badly polluted by the sewage of Buffalo. As an example of a lake city that slightly pollutes the water of its neighbors may be mentioned Milwaukee, where the drift of the polluted water extends as far as Cudahy, but even the Cudahy supply is polluted more by its own sewage than by that of Milwaukee.

Each city also has the remedy in its own hands, namely, the purification of its own water supply.

At the present time there is no general pollution of the lake waters worthy of serious consideration and no general pollution problem is likely to arise for many years. The nearest approach to a general problem is at the southerly end of Lake Michigan where Chicago and a number of large cities are relatively near together.

Fearing lest a general pollution problem might arise in this region, and hoping to secure concerted action on the part of the lake cities to protect the quality of the lake water, the Lake Michigan Water Commission was organized in 1908. It is comprised of public health officials, engineers, water analysts and others from the states of

Wisconsin, Illinois, Indiana and Ohio, from the lake cities themselves, with representatives also from the United States Public Health and Marine Hospital Service. The Commission has held several annual meetings and its papers contributed have been helpful in stimulating the interest in the general problem.

In 1911 a more extended organization, known as the Great Lakes International Pure Water Association was projected and a temporary organization formed.

As sources of inspiration and as centers of scientific discussion, such organizations are of real service. But, inasmuch as each problem is a local one, it is difficult to see how concerted action can be or need be brought about. Nor does it appear that interstate or international arrangements are necessary in order to bring about local reforms. Scientific co-operation is needed much more than legal co-operation or the promulgation of general laws bearing on the subject.

The instances where the sewage of one city affects the water supply of another, as Detroit and Buffalo, or Milwaukee and Cudahy, are in almost every case contained within the limits of a single state. No international problems of water pollution of any great importance are likely to arise in the near future.

Nevertheless the United States Government can, through its Public Health Service, perform a useful service by bringing its influence to bear on individual cities, pointing out the dangers and recommending action where needed. Through its impartial position such recommendations carry weight. The power to compel action by the negligent lake cities naturally lies with the state in which the city is located rather than with the federal government.

It is evident from what has been said that some very important scientific studies need to be made to determine the laws that control the currents of the lakes and influence the dispersion of the sewage discharged into them. But it is not necessary to wait for such studies or to await further developments in the art of sewage treatment, as the obvious remedy for the protection of the lake water supplies is filtration of the water, with provision for its disinfection, if necessary. With the art of water purification so fully developed as it is, so thoroughly tested by experience, and proven to be reliable, no lake city can afford not to adopt this safe and sane method of protecting its citizens against the disease and death that lurk in sewage contaminated water supply.

DISCUSSION

Mr. P. A. Maignen.—Mr. Whipple is to be complimented for his excellent paper. We can never tire of hearing so clear an explanation of facts from one so well versed in his subject.

To enlarge the scope of the discussion I would like to ask Professor Whipple a few questions:

Will he tell us what, in his judgment, is the cause or modus operandi of the loss of free oxygen in water?

What is the influence on health of the presence in drinking water of the larger micro-organisms concerning which he has written so ably; and, is this influence exerted to the same degree in summer and in winter?

A few years ago, upwards of ten thousand analyses were made in the speaker's laboratory with Schuylkill water. The average count of bacteria in winter was 60,000 colonies per c.c. at the inlet to the settling reservoir at Lower Roxborough, which holds about 24 hours' supply. At the outlet the average count was 90,000 colonies. In the summer the inlet gave 6,000 colonies and the outlet 3,000. Here is a very interesting observation—a considerable increase in the winter and a still larger decrease in the summer. Surely this is a subject worthy of the most serious investigation.

Cold is supposed to check the growth of bacteria in water and here we have absolutely the reverse; in fact, the highest counts were found when there was a sheet of ice on the water. Sedimentation is supposed to purify the water. This seems to be true in the summer, but not in the winter. Why?

Is it because in the summer the larger micro-organisms or protozoa such as the parameciae, rotifers, volvox, and the like, are extremely lively in eating the small bacteria as big fish eat the little fish? In the winter the larger fellows seems to go to sleep, they are hardly to be seen anywhere in the water, so it would seem as if, at this time, the smaller bacteria had the field all to themselves.

I would like to ask Professor Whipple if he has ever observed this co-existence of the protozoa and bacteria in summer, and the absence of the former in winter.

I wish also to ask if any observation has been made as to the presence or absence of the protozoa in water known to have produced typhoid fever. These protozoa seem to be always present in water in which any kind of dead organic matter is undergoing decay, in fact they seem to be the chief instruments of the decay.

There are, as we all know, a considerable variety of protozoa. Some live a few months and others a few weeks. Some multiply so fast that very little room is left for any other kinds. Most of them are poisoned by the product of their own metabolism. If you want to keep them alive you have to give them fresh water and fresh food; if not, they die in their own juice; others die for want of appropriate food; whilst others again seem to live a considerable period of time on soluble matter. One rule is constant, if you give them fresh water you see them multiply very quickly. This would perhaps account for observations made with sewage. Dilution of water with sewage does not necessarily mean a lesser number of micro-organisms; on the contrary, the fresh supply of water seems to facilitate their multiplication.

I should also like to know what other diseases besides typhoid fever have been reduced by filtration?

I think the question of oxygen in water is an exceedingly interesting one. It reminds me of some observations which I have made for many years and as late as this afternoon. Place a drop of water infusion on a slide without spreading it, the drop will therefore be convex. If you focus the microscope so as to see the outer surface of the drop, you will see one kind of protozoa and one kind only; if you lower the microscope a little, you will strike another layer with another kind of micro-organisms, and finally if you reach the base, you will see some other species of protozoa and if there be any bacteria present, they are usually to be seen at the bottom. Some seek the air and go to the surface. It is perhaps of this kind that we speak when we say that the micro-organisms are aerobic. Others go to the bottom—I suppose these are anaerobic. Would it then happen that the free oxygen in water is appropriated by the protozoa which seek the upper layer of the water?

A last question: Would Professor Whipple tell us how often the typhoid bacilli has been found in water? It is, of course, cultivated in laboratories, but I understand it is se dom sought for in the water supply. Its cousin, the coli commune, is always sought as evidence of sewage pollution.

Professor Whipple.—We believe it has been found a few times, but just how many I do not know.

Mr. Maignen.—Suppose a dead horse is thrown into the river, what are the kind of micro-organisms that w.ll first appear on the scene to devour it? Any information on these different subjects would be very much appreciated.

Mr. Webster —We are indebted to Mr. Whipple for his very interesting paper on the water supply of the Great Lakes and the movements of the currents which tend to carry pollution to water supply intakes, and also the discussion on the disposal of sewage by dilution. It is very evident that engineers are learning that the treatment and purification of sewage in this manner must be considered among the available methods.

It is now recognized that streams flowing through populated areas are unfit for water supply without purification and that the sewage of towns draining into such streams must be treated to an efficient degree, but not necessarily purified. By this I mean that the sewage must be treated to such an extent that it will not place an overload of organic matter upon a water purification works nor create a nuisance in the waters into which it is discharged. A great work will have been accomplished by any large city when its sewage is treated to such an extent that it meets these requirements.

It has been suggested that calcium hypoclorite would be useful in the treatment of sewage. It may be used to great advantage in certain cases as a protection to valuable shell fish layings or in time of epidemics, but for our large cities the cost of constantly treating sewage with hypoclorite of calcium would be prohibitive, and as a means of purification without any other treatment it would not give satisfactory results, as the chemical would disinfect the surface only of the large particles of organic matter and prevent the decomposition of the interior for a time, so that when these larger particles became broken up, decomposition would develop.

Mr. S. M. Swaab.—How far from the shore is that intake?

A. About 7,000 feet from the shore, and the intake is 40 feet below the surface.

DIAGRAM No. 2.—"When the wind was blowing toward the shore, the warm water was driven toward the shore. The temperature of that water was over 60°. In this case the tendency will be for the sewage to flow away from the shore rather than towards it.

PROF. WHIPPLE.—It is true that the larger forms of life thrive better in summer, and are therefore most likely to destroy bacteria in that season. It is a fact that we almost never have typhoid fever outbreaks in summer weather due to water infection. Such outbreaks nearly all occur in the fall or the spring when the weather is relatively cold. Some interesting facts have been learned in regard to the life of the typhoid bacilli. We have known for some time that these germs live longer in cold water than in warm water. Just why has not been found out, but the bacteriologists are beginning to employ statistical methods Starting with a known number of typhoid bacilli added to water, and observing how they decrease from time to time they have plotted the results on logarithmic paper and find that the points tend to fall on a straight line. That is the typhoid germs decrease in number logarithmically. The slopes of the lines are different for different temperatures, the disappearance being more rapid in cold water than in warm water Dr. Loeb, of the Rockefeller Institute finds two processes going on in natural life, processes of death as well as processes of life. The life processes are very materially increased by an increase in temperature; but the death processes are increased still more. On the other hand, as the temperature falls, the life processes are decreased somewhat, but the death processes are not increased as fast in proportion. And that explains —if we may call it an explanation—why it is that in the high northern latitudes, we find an unexpected abundance of microscopic life. The water there contains a great many more microscopic organisms than in the water farther south, because the death processes there do not take place as rapidly as the life processes. Just what these two processes are, I do not pretend to say.

As to some of the other questions that Mr. Maignen asked, I do not know that I can tell by name what other diseases are reduced by filtration, other than typhoid; but we do know that often when bad water is made good by filtration, not only does the death rate from typhoid fever decrease, but that the death rates from pneumonia and tuberculosis and other diseases that are not usually attributed to the water we drink also decrease.

MR. MAIGNEN.—You did not answer my question as to what is the cause of the loss of oxygen.

PROF. WHIPPLE.—I do not know that I can answer that except in a general way. Fish require a certain amount of oxygen, quite a large amount. I presume that most of you know by experience that when the children go away for the summer and leave the little gold fish in your charge, the fish usually die; not because of lack of care on your part, but because the little jar is too small to allow the absorption of sufficient oxygen from the air for the life of the fish. Microscopic organisms and some bacteria need a certain amount of oxygen.

MR. SWAAB.—' ... oride can be used economically and to much bet- ... v. Of course, there are times when the water

supply may fail, the mains may break; but in that case, I believe the precaution should be taken of having at hand means of treatment of the water supply. We cannot hope to get that protection from the sewage. This question of treatment of sewage is largely an economic one, and it is the duty of the sanitary engineer to take advantage of all those forces of nature that he has at hand. The great reforms that we looked for years ago are now, I think, practicable. Engineers are now speaking of "sewage treatment" and not sewage purification.

MR. VOGLESON.—I have been very much interested in what Professor Whipple has told us. If I remember correctly, he said that in the disinfection of water supplies, the practical results did not bear out the theoretical formulae. In the application of disinfection we run across a great many difficulties in regard to getting the service we desire, and I would like to ask if the difficulty in approaching the theoretical efficiency is not one which may be overcome by thoroughness in practical details.

PROF. WHIPPLE.—In regard to that, I would say that if the disinfectant is thoroughly mixed, and used in proper quantities there cannot be any question of its effectiveness, but I have seen many cases where it is impossible to get the intimate mixture that is necessary. You cannot discharge the solution through a pipe down into an aqueduct and expect to get a good mixture; sometimes it is necessary to resort to some special means to agitate the water and get the chemical thoroughly mixed. In so far as mixing fails, the process will fail.

ABSTRACT OF MINUTES OF THE CLUB

Joint Meeting of the Engineers' Club and the Philadelphia Chapter of the American Society of Mechanical Engineers, October 5, 1912

The meeting was called to order by Vice President Plack at 8.35 P. M., with 72 members and visitors in attendance. The minutes of the business meeting of September 21st, were approved as printed in abstract.

Mr. George H. Perkins, of the Lowell Institute of Technology, spoke on the Exhibition for the Abatement of the Smoke Nuisance held in London in the spring of 1912.

Mr. O. R. McBride, of the University of Pittsburgh, read a paper, entitled, "Methods and Means of Smoke Abatement." The subject was discussed by Messrs. H. F. Morris, Chief Lukens, of the Bureau of Boiler Inspection, Mr. W. C. Furber, Dr. Howard S. Anders, Dr. Herman B. Allyn and others. On motion of Mr. E. S. Hutchinson, a vote of thanks was extended to Mr. McBride and Mr. Perkins.

Regular Meeting, October 19, 1912

The meeting was called to order by Vice President Plack at 8.35 P. M., with 68 members and visitors in attendance. The minutes of the Joint Meeting of the Philadelphia Chapter of the American Society of Mechanical Engineers and the Engineers' Club, held October 5th, were approved as printed in abstract.

The Secretary announced that the following had been elected to membership by the Board of Directors at their regular meeting held October 17th, 1912: Active—G. Walker Gilmer, Jr., and Jonathan Jones; Junior—Fred M. Schilling and C. Carroll Sloan.

Mr. C. D. Watson presented the paper of the evening, entitled, "The Development of Separately Moulded Structural Concrete," which was discussed by Messrs. S. M. Swaab, John C. Trautwine, Jr., Edward S. Hutchinson and Prof. H. C. Berry.

Regular Meeting, November 2, 1912

The meeting was called to order by President Hess at 8.40 P. M., with 75 members and visitors in attendance. The minutes of the Regular Meeting of October 19th were approved as printed in abstract.

Professor G. C. Whipple presented the paper of the evening, entitled, "Sanitary Protection of the Water Supplies Taken from the Great Lakes," which was discussed by Messrs. P. A. Maignen, G. S. Webster, John C. Trautwine, Jr., S. M. Swaab, Wm. Easby, Jr., J. A. Vogleson, Prof. Whipple and others.

On motion of Mr. Trautwine, a vote of thanks was extended Prof. Whipple.

Business Meeting, November 16, 1912

The meeting was called to order by President Hess at 8.40 P. M., with 205

members and visitors in attendance. The minutes of the Business Meeting of November 2nd, 1912, were approved as printed in abstract.

The Committee on Nominations presented the following nominations for officers of the Club for the year 1913: President, W. P. Taylor; Vice President, S. M. Swaab; Secretary, E. E. Krauss; Treasurer, J. Reese Bailey; Directors, J. E. Gibson, Manton E. Hibbs, H. Clyde Snook, F. K. Worley.

The following were reported as having been elected to membership by the Board of Directors at their meeting of November 14th, 1912: To Active Membership—Harold Marcus Leh, John S. Ely; Junior Membership—Walter Stokes Fogg, Norman Dudley Fulton, Edward H. Robie.

Mr. Henry M. Neely presented the paper of the evening, entitled "The Mechanics of the Aeroplane," which was discussed by Messrs. E. G. Perrot, C. W. Bell, H. Goodwin, Jr., Carl Hering, W. C. Furber, S. M. Swaab and M. E. Reid.

On motion of Mr. Quimby, a vote of thanks was extended Mr. Neely.

Business meeting, December 7th, 1912:

Business Meeting, December 7, 1912

The meeting was called to order by President Hess at 8.35 P. M., with 97 members and visitors in attendance. The minutes of the business meeting of November 16th, 1912, were approved as printed in abstract.

Mr. B. A. Haldeman presented the paper of the evening, entitled, "The Planning of City Streets," which was discussed by Messrs. George S. Webster, H. H. Quimby, B. A. Haldeman, W. C. Furber, S. M. Swaab, Henry Hess, E. M. Nichols and H. M. Chance.

Business Meeting, December 21, 1912

The meeting was called to order at 8.35 P. M., by President Hess, with 100 members and visitors in attendance. The minutes of the Business Meeting of December 7th were approved as printed in abstract.

It was announced that the following were elected to membership at the meeting of the Board of Directors on December 19th: Active—J. Willard Gamble, Silas G. Griffith, Paul C. Haldeman, Allen S. Hurlburt, John J. Young, Jr.; Junior—Edward H. Blum, Chas. C. Campbell, Alexander P. Gest, Jr., T. Otto Mayer and David M. Niver.

The following additional nominations were presented:

For President, Mr. W. L. Plack, endorsed by Messrs. Joseph T. Richards, Frederick W. Abbott, Chester E. Albright, Walter Loring Webb, Henry L. McMillan, Alfred D. Morris, E. M. Nichols, Herman Livingston, A. M. Loudenslager, F. S. Crispin, J. Chester Wilson, Harrison Souder, John A. Carlisle.

For Director, Mr. H. M. Chance, endorsed by Messrs. Walter Loring Webb, Henry L. McMillan, E. M. Nichols, Herman Livingston, J. Chester Wilson, Harrison Souder, John A. Carlisle, W. Copeland Furber, Charles F. Mebus and J. Lawrence Hagy.

Mr. F. C. Robinson presented the paper of the evening, entitled, "Manufacture of Petroleum Products," which was discussed by Messrs. W. M. Irish, Wm. T. Price, John C. Parker, Henry Hess, S. M. Swaab, W. C. Furber, Carl Hering, and others.

A vote of thanks was extended to Mr. Robinson for his paper.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

REGULAR MEETING, October 17th, 1912.—Present: President Hess, Vice President Plack, Directors Kerrick, Worley, Develin, Gilpin, Haldeman, Swaab, Yarnall, the Secretary and the Treasurer.

The Treasurer reported a net gain to October 1st of $854.04.

The following resignations were accepted: M. K. Bryan, George E. Dale, R. K. Matlock, L. A. Sagendorph, H. A. Rogers, Wm. R. Webster.

The President and Treasurer were authorized to negotiate a temporary loan for sixty days, the Finance Committee to recommend the amount.

The following were elected to membership in the Club: Active—G. Walker Gilmer, Jr., Jonathan Jones; Junior—Fred M. Schilling, C. Carroll Sloan.

Malcolm R. Maclean was transferred from Junior to Active membership.

Communications from the Water Conservation Association and the British Fire Prevention Committee were referred to the Committee on Public Relations for action.

REGULAR MEETING, November 14th, 1912.—Present: President Hess, Vice President Mebus, Directors Halstead, Kerrick, Gilpin, Vogleson, Haldeman, Swaab, Yarnall and the Secretary.

The Treasurer reported that C. F. Morrall had been dropped from the roll, in accordance with the By-Laws, on account of the non-payment of his initiation fee.

The following members were dropped from the roll for non-payment of dues: R. D. Allen, T. H. Boorman, E. Cunningham, Wm. McClellan, H. G. Perring, H. S. Righter, Wm. T. Ruth, W. A. Smethurst, J. Walter Ward and E. H. Wray.

The accounts of the above were ordered to be cancelled on the books, and listed in a special ledger.

The resignations of R. K. Sheppard, Philip L. Spalding, George L. Thompson, J. A. Colby, John Horridge, Wm. G. Bickell, Carroll W. Simon, F. K. Wilkinson, E. S. Morrell, M. Monaghan and W. K. Martin were tabled.

The report of the Finance Committee was read and approved, and the matter of the first mortgage referred back to the Committee, with instructions to renew the mortgage for a period of five years, if possible.

The Membership Committee's report was read and approved, and the following were elected to membership: —Active—Harold Marcus Leh and John S. Ely; Junior—Walter Stokes Fogg, Norman Dudley Fulton and Edward H. Robie.

The following Juniors were transferred to Active membership: G. L. Watters and Arthur C. Merrill; to Associate membership, T. Joseph Reilly.

The Committees on Publication, Meetings, Publicity, Advertising, Public Relations had no reports to make.

The report of the House Committee and of the Library Committee were read and approved.

The Business Manager's report was read and approved.

Owing to the fact that a legal quorum was present, on motion, all former actions of the Board were ratified.

A special sinking fund was authorised to be created for the purpose of liquidating second mortgage bonds and building notes, the conditions covering this sinking fund to be determined later.

The following changes in the rules for the government of the Board of Directors were adopted: Following the reading of the Minutes, "All resolutions and motions passed at the previous meeting be read and corrected or approved, as the case may be."

It was also resolved that no resolution shall be voted on until it has been fully reduced to writing, read and approved by the propounder and his seconder.

Regular Meeting, December 19, 1912.—Present: President Hess, Directors Halstead, Kerrick, Develin, Gilpin, Vogleson, Haldeman, Swaab, Worley, Yarnall, the Secretary and the Treasurer.

The minutes of the meeting of November 14th and the motions and resolutions of the meeting of November 14th were read and approved.

The Treasurer's report was read and approved.

The Secretary's report was read. A resolution, relative to Mr. Plack's resignation was passed, as follows:

"*Resolved*, that it is the sense of the Board of Directors of the Engineers' Club of Philadelphia that it would be extremely unfortunate for the Club to lose the services and association of Mr. W. L. Plack, who for many years has served the Club earnestly and efficiently. We therefore ask that Mr. Plack seriously reconsider the matter of his resignation."

Mr. E. S. Morrell's resignation was accepted as of December 31st, 1912.

The reports of the Finance, Library, House, Advertising, Public Relations and By-Laws Committees were read and approved.

The report of the Membership Committee was read and approved, and the following were elected to membership: Active—J. Willard Gamble, Silas G. Griffith, Paul C. Haldeman, Allen S. Hurlburt, John J. Young, Jr.; Junior—Edward H. Blum, Charles C. Campbell, Alexander P. Gest, Jr., T. Otto Mayer, David M. Niver. John Horridge and John A. Remon were transferred from Junior to Active membership.

The Business Manager's report was read and approved.

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solved that the Board authorize the renting of desk space or a room to the Aero Club, to be used by only the Secretary and President of the Aero Club, and the Board referred to the House Committee for its recommendations to the Board the matter of rental to be charged.

The Secretary was instructed to inform the Board of Directors of the Aero Club of Pennsylvania, at their meeting to be held December 20th, at 3.30 P. M., as to the action taken by the Board in the matter.

Fig. 10.

civic or social centers. The municipal authorities cannot directly control the drift of business, but they can control the location of libraries, schools, public halls, gymnasiums, playgrounds and baths, branch offices of the central government, fire houses, police stations and other buildings necessary to the proper administration of the public business; these public buildings, properly grouped, form the civic or social center and by reason of being the center of the social, educational, and official life of the community will attract hotels, theaters and general business. These centers should be planned in such a manner that traffic may have an option of passing either through or around them so that congestion in them may be avoided. The village "green," characteristic of all New England towns, is the embryonic type of what such a center should be. It is a somewhat sad commentary upon the wisdom and skill of some of the more modern town planners to say that the men who laid out the American towns of a century or two ago were wiser than they in their appreciation of the value of civic centers and open spaces for the use of the people, that those town planners of the long ago established a custom which, after having been abandoned for more than a century, has become one of the vital issues of the new town planning, and that the restoration of the park and the open public place is due to the active interest of private citizens and associations in civic affairs.

Parks, playgrounds, and other open spaces for the use and enjoyment of the people have come to be recognized as essential features of modern urban improvements and should be provided for on every plan of street extension. The selection and distribution of such places can be more intelligently made in connection with the establishment of traffic streets than if left until residential or other development has commenced and the value of land has advanced.

With an efficient system of traffic streets firmly established, other parts of the plan, covering residential streets and those which can never be of much importance to through travel, should be left as elastic as possible in order that any legitimate form of development may be accommodated. Industrial sections, high class residential sections, and sections given to the modest type of dwellings, each require a different treatment of the street plan. In factory districts the streets surrounding industrial plants should be wide and straight while those in the same vicinity upon which the homes of the workmen front may be of a quite different type; some of the garden

space to be paved between houses, the idea apparently being that the municipality could not afford to construct or maintain anything there except paving and such unlovely objects as telegraph, telephone, and trolley poles; we shall probably find in the future that considerable of this area can be used for grass plots and trees, that the cost of maintaining them properly need not be prohibitive, and that the attractiveness of the streets will be immeasurably enhanced; it will be interesting to note whether this change, which is certain to come, will result from intelligent and well-directed efforts on the part of the public authorities or allowed to go by default until it is forced by political or private agitation.

Competition is as keen among cities as it is among individuals and skilful advertising is as necessary in establishing and maintaining a city in a position of eminence as it is in assuring success in business; the most effective advertising of the city is accomplished through the agency of the street and its furnishing and the opportunity and encouragement it gives for expressing the civic pride and ambition of the individual and the community; a city whose streets are uniformly commonplace and monotonous will never inspire its citizens with a very high order of civic pride or patriotism, nor will it engage the earnest attention, admiration, or respect of the visitor. One reason why Philadelphia is not more favorably advertised and more widely commended is because she has so little of the dignity, beauty, and charm that arms her citizens best in defence against criticism and that attracts the interest and applause of the tourist and the casual visitor; if we are to achieve and maintain any position of distinction as a world-interesting city we must cultivate a larger appreciation of civic art and apply it more industriously in connection with the doing of such big and progressive things as are making other American cities famous, helping to attract the world to Europe and turning a strong tide of world-travel toward the ambitious cities of South America.

There are two classes of streets in foreign cities that are the delight of tourists; one is the narrow thoroughfare of the olden time, full of angles and offsets, curious gables, picturesque open spaces and quaint buildings; the other is the wise, dignified, tree lined avenue or recent years, flanked by stately buildings bearing the finished touch of the most skilled architects. Our American cities offer little in either of these classes; the picturesque passageways of the Middle

Ages will never be reproduced and we seem unable or unwilling to properly develop the grand avenue of modern times; the wide streets we have are either a waste of desolate paving or the attempt to rescue them from that condition, which has resulted in grotesque combinations of various schemes devised and carried out with the best intent by individual property owners but without proper advice, control, or supervision, and only occasionally do we find a street or a neighborhood where all the surroundings give expression to a well-ordered and harmonious conception.

American cities lead the world in the beauty and charm of their suburbs, but as urban improvements are pushed outward much of this is destroyed by inflexible insistence upon some formal scheme of development, regardless of the character of the street or the nature of the adjacent territory. With all our boasted wealth and progress, our great municipalities have failed dismally in both the efficiency and attractiveness of our streets and roads; the best we have to show, with few exceptions, is in our smaller towns or where the development has been due to broad-gauge private enterprise.

No plan of a city has been well or wisely conceived unless the citizen can find pleasure and enjoyment in his surroundings as he traverses its streets; no plan is complete unless it offers the pedestrian something to repay him for his wanderings and some enticing place where he may halt to rest, whether it be in some quiet side street in contemplation of a garden, a fountain, or a statue, or in the midst of the rush and roar of traffic in contemplation of man's strenuous struggles in the world of trade; no street is well planned unless it expresses an intelligent conception of the uses to which it and the property bordering upon it may be put, and invites and encourages those legitimate uses in their best estate.

DISCUSSION

Mr. S. M. Swaab.—I noticed in the pictures of some sections of suburban property around Philadelphia half a dozen telegraph poles. Do they have them abroad?

A.—In most cases the wires are carried over the buildings and poles are erected in the yards or attached to the buildings.

Mr. Swaab.—In the case of the elevated railroad in Berlin were the planted to hide the structure or were they there before?

Chairman.—I happen to know that section; the trees were plan

MR. SWAAB.—If you had some pictures of the Berlin elevated, you could show one of the handsomest elevated railway structures in the world.

MR. HALDEMAN.—Well, I was not particularly impressed with the design of the metal structure.

CHAIRMAN.—They have endeavored to make this elevated structure as nearly noiseless as possible.

MR. HALDEMAN.—It is very nearly noiseless. Not only are the elevated roads of Berlin operated very silently, but all the surface roads in the German cities are so operated. I do not think you will hear bolts, chains or other loose parts rattling on their cars, there are no flat wheels or anything of that kind.

MR. WEBSTER.—Mr. Haldeman has given a very clear demonstration of the difficulties encountered in proper street planning; also in the planning of a large city. Laying out a new town in virgin country represents a problem which is very difficult to solve and requires the best skill of the Town Planner. It is almost impossible for any one to determine—I might say it is almost impossible for any one to make an intelligent guess—as to how such a town in its long years of development is going to grow. Consideration must be given as to conditions which may develop which will change the attitude of the local government, the advent of one or two lines of steam or electric railroads may change what was planned originally to be a residential section into a manufacturing district, and in the laying out of streets it must be realized that those to be used for business and transportation purposes must necessarily be wider than those in residential sections. In fact, in planning a small town, to lay out wide streets in a residential district would not only be undesirable, but would place an unnecessary cost for street improvements upon owners of the land. In Philadelphia, who, twenty-five years ago could have forseen the great concentration of people which occurs daily in the vicinity of Broad and Market Streets, which is due largely to the advent of the department store and the large office building, which accomodate thousands of people? This has placed upon the city new obligations which were neither anticipated nor provided for.

In the growth of our cities it is necessary not only to provide for the accommodation of the people upon the surface of the street, but it is also necessary to make provision for those underground structures which are so essential to their comfort and convenience. To supply those necessaries of life which modern civilization demands, all kinds of sub-surface structures are required; the sewer and water pipe were probably the only ones anticipated one hundred years ago, but now provision must be made for conduits to carry telephone and telegraph wires, pipes for gas, pneumatic tubes and other similar structures which in the future will increase in numbers and size. On the principal streets in the business center of the large city the demands of transportation require that subways be constructed in order that the people may have a quick and economical conveyance between their homes and places of business. These demands both on the surface of the street and underground are such that in the older cities they can only be met by laying out new streets or the widening of existing thoroughfares.

but there is no reason why all the large department stores and other high class stores should be there. One of the principal objects of city planning is to discourage the creation of one congested center and to encourage the growth of business centers in various parts of the city. All large cities are beginning to realize the evils of concentration and of crowding all business into one center.

MR. W. C. FURBER.—In the course of Mr. Haldeman's very excellent address on Town Planning, he made one statement in regard to the tendency of town development toward open spaces and toward separate dwellings. I have been attending the sessions of the National Housing Convention in Philadelphia during the past week, and I have been surprised and amused at some of the expressions of opinion regarding the Philadelphia method of laying out streets, which, in my opinion, are largely due to ignorance. I thought our wide streets and detached houses were pretty nearly the right thing, but in these various conferences where these subjects came up, the expressions of opinion were anything but favorable toward the Philadelphia methods. One speaker said that some of our Philadelphia detached houses were put up in Newark, N. J., and they had been unable to rent them; that the Newark people preferred the two-decker flat, on the theory, I suppose, that the builder could rent the upper part and live in the lower part himself, leaving the upper one to take care of his overhead charges It was also stated that in New Rochelle people are giving up private houses and living in flats. The speaker was now living in a flat by choice. In analyzing these methods, he emphasized the difficulty of securing cooks and servants, and he thought that in future, skeletons of cooks and servants would be preserved in the museums. He also referred to the difficulty of getting houses provided with hot water, and conveniences for the removal of ashes, etc., and he thought the progress of modern development was in favor of doing these things in a communal way, which would be better than in an individual way, which, of course, has the merit of truth.

The best possible way towards the development of the individual house in the way of a combination of general utilities, is in the Girard Estate, at 17th and Shunk Streets, we all know that is a popular development in Philadelphia.

Mr. Haldeman spoke of the unfortunate development of cities in the ways they were not expected to go, and I never ride out to Willow Grove but it makes me feel sad to see the pushing of the two-story or three-story operation house out into that beautiful country. I think it is this side of Logan that there is a development of two-story houses that jar your sense of the fitness of things, as you compare them with the beautiful landscape with which tl rounded. It may be otherwise some day, but it is inevitable as long the private ownership of land and where the sole object is tl the owners.

MR. S. M. SWAAB.—I am not very much of a political economist, like to ask my friend Mr. Haldeman whether those European metho out streets is not really a matter of economy more than anything

What impressed me particularly in the pictures that Mr. Halde was the vast quantity of foliage and trees in the continental cities, siderable distances between the buildings. It seems to me that o

also. On narrow streets no new buildings can be put up to the old line, but must be set back to a new line, thus insuring a wide street after a while.

MR. SWAAB.—We have the same thing in Philadelphia. We have it on every street, Arch Street, Walnut Street, and other main streets.

CHAIRMAN.—Mr. Haldeman referred to the desirability of a park setting for our City Hall, to which some exception was taken as placing the City Hall more remote. It is not necessary to occupy great width to secure park effect. Many European cities have such settings for large public buildings, but the space occupied to make these surroundings is not actually large enough to cause anyone to become leg-weary. But the treatment does demand skill. Speaking of our own City Hall, I think it would do no harm at all if we had a few trees to hide it.

Much mention was made of the fact that our Philadelphia business is concentrated. That is not a necessary characteristic of a large city; but is a village practice. The business of our town while small was concentrated around the City Hall a long time ago; and a great many people, not Philadelphians, and a few who are, hold it a reproach that it should still be so. It is a small town view still largely held by a great many; take, for instance, this Club, this meeting would be much better attended if it were within one and a half or two blocks of the City Hall, instead of four. We have not yet caught up with our growth.

The real cause of the high cost of living in European cities is Europe's militarism, not only does it cost a good deal to maintain a soldier or a sailor, but this taking a man out of industrial life and putting him in the army or the navy deprives the community of a self supporting and a contributing member and adds an eating member whom the others must support; and in that you have basic cause for the high taxation prevailing in Europe. We here save that, but are like the woman who, saving a dollar, feels rich enough to spend two, and does.

MR. HALDEMAN.—In reference to the economy of the wide streets of Continental cities, I will say that the individual street does cost more than ours, but the percentage of street area is much less than in our big American cities. Nearly one-half the area of Manhattan Island is occupied by streets; in Philadelphia the street area varies from 30% to 50%; in Berlin it does not exceed 20% to 25%.

MR. FURBER.—The character of a street is determined by the character of the buildings upon it. You pointed out the superiority of the large flat house. With proper facilities for living in, that is quite an institution. I think we believe that that type of building is infinitely to be preferred to our cheap, two-story house that we are familiar with in Philadelphia, and as you have also pointed out, that the unit cost per square foot of street serves up a reason for this increased density of population, which makes it easier to compare with our development.

CHAIRMAN.—People who live in those flat houses must suffer a certain amount of regulation, which I do not think we would submit to in Philadelphia. If

PAPER NO. 1122.

THE MANUFACTURE OF PETROLEUM PRODUCTS

By Dr. F. C. ROBINSON

Chief Chemist of the Atlantic Refining Co.

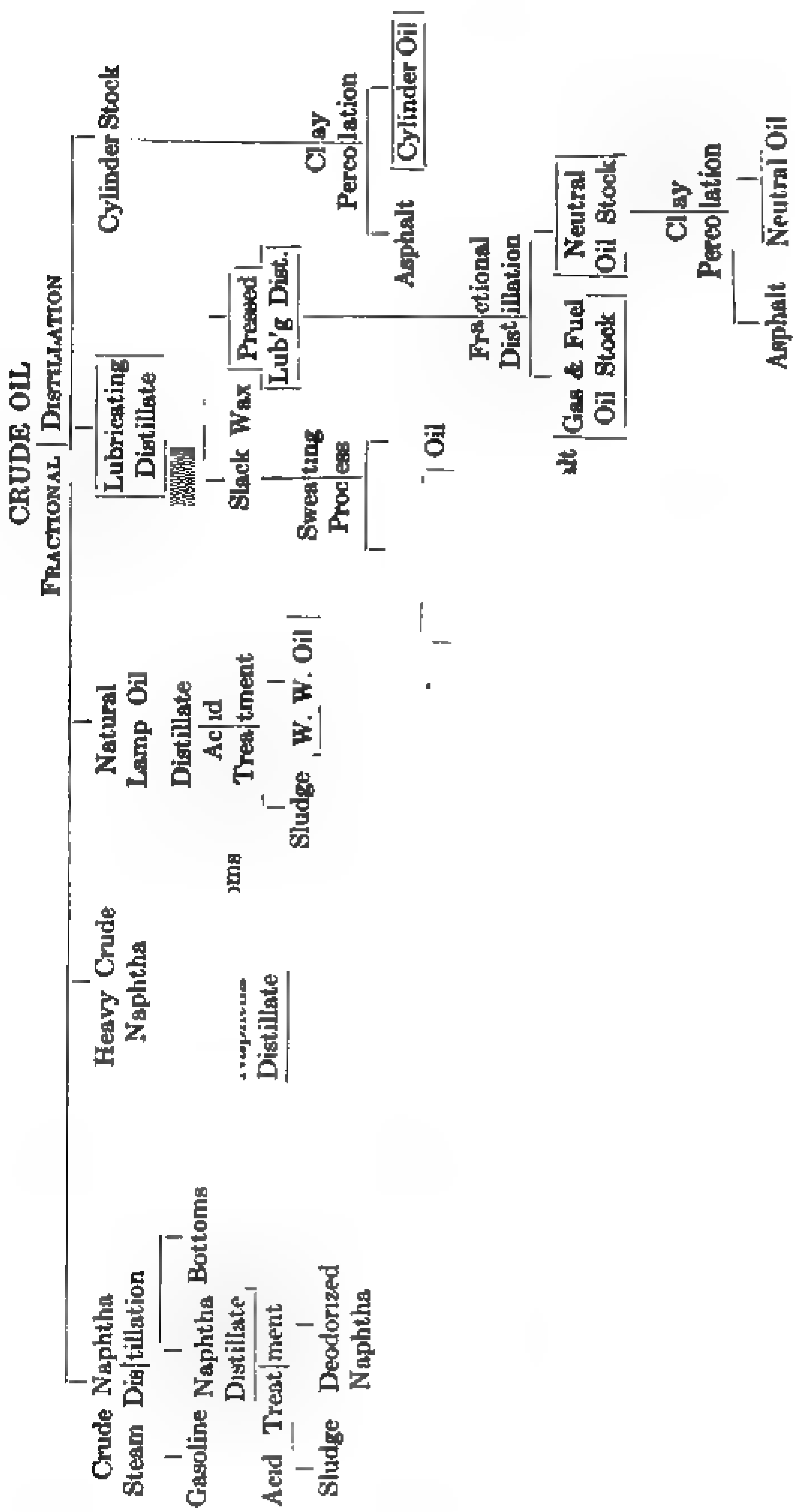
Read December 21, 1912

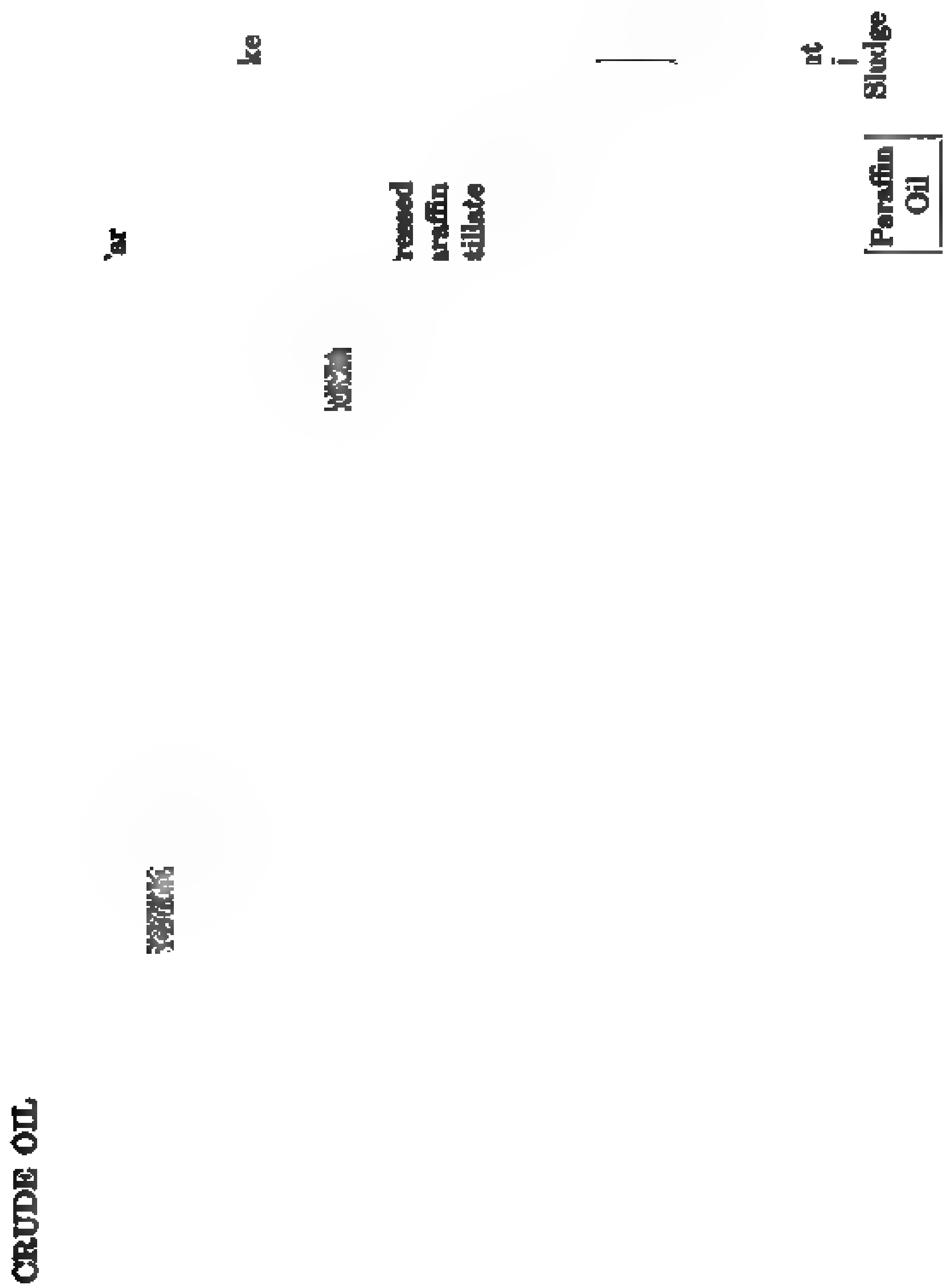
It is a real privilege to address you, a body of engineers, on the present subject—The Manufacture of Petroleum Products—because all of these products are or might be used in some engineering operation. I have frequently had occasion to inform my friends that the oil refinery does not manufacture dyes, acetanilid and allied products, nor perfumes. We do not make perfumes.

The first group of products from petroleum is made up of Gasolines and Naphthas. There is some confusion among the various names, benzine, gasoline, naphtha, etc., but the best practice is to use the word gasoline for any mixture of light hydrocarbons intended for use in any kind of vaporizer, *i. e.*, to be gasified in a gas machine, gasoline torch, gasoline stove or automobile carbureter. Also to confine the word naphtha to mixtures of hydrocarbons intended for some purpose that requires a very good odor, such as the naphtha used by cleaners, varnish makers, soap makers, etc. In this scheme, the word benzine finds no place. Gasolines and Naphthas vary in average boiling point according to the use for which they are intended, but all lay between 125° F. and 280° F. In all cases it is essential that they be free from all heavy hydrocarbons that do not evaporate from the hand.

The next group consists of several grades of Lamp Oil. Lamp Oil is a mixture of hydrocarbons whose average boiling point is about 450° F., entirely freed on the one hand from gasoline or naphtha and on the other hand from the heavy hydrocarbons that belong to Gas Oil and Lubricating Oil and that would make the oil act badly in the lamp.

The next class is gas oil. While oils of all degrees of volatility have been used, the most economical for the gas maker consists of


CRUDE OIL
FRACTIONAL DISTILLATION
Crude Naphtha
Steam Distillation
Gasoline Naphtha Distillate
Bottoms
Acid Treatment
Sludge
Deodorized Naphtha
Heavy Crude Naphtha
Distillate
Natural Lamp Oil Distillate
Acid Treatment
Sludge
W. W. Oil
Lubricating Distillate
Slack Wax
Pressed Lub'g Dist.
Sweating Process
Oil
Fractional Distillation
Gas & Fuel Oil Stock
Neutral Oil Stock
Clay Percolation
Asphalt
Neutral Oil
Cylinder Stock
Clay Percolation
Asphalt
Cylinder Oil


Sludge
Paraffin Oil
CRUDE OIL

The next group—The Road Binders—consists of petroleum asphalt properly fluxed with heavy Petroleum Oils that will not evaporate and of such qualities that they will bind the road materials together both in summer and winter.

The next group—Coke—contains but one member. This material being almost entirely free from ash, is used very extensively by makers of Electric Carbons.

1. These are the desired products. Now let us look at the Crude Oils from which they are obtained.

2. There are about as many varieties of crude oil as there are oil fields, but the refiner recognizes three distinct types, because each type must be handled by different methods. *Viz.* (1) The paraffin base crude similar to that found in Pennsylvania and West Virginia and being essentially light colored crudes containing paraffin. (2) Asphalt Base Crudes similar to those found in Texas and California and being essentially black and containing no paraffin. (3) Mixed Base Crudes similar to those found from Ohio to Oklahoma and being essentially mixtures of paraffin and Asphalt Base Crudes.

3. In order to obtain some idea of the chemical and physical nature of the crude oil let us imagine a sample of Mixed Base Crude brought into the laboratory for a thorough examination. The Chemist would probably distill the sample in a vacuum or in some similar manner in order to avoid destructive distillation and would save the various fractions separate. He would not distill off more than 90% because the heaviest 10% cannot be distilled without breaking it down into simpler molecules. He will then start to examine the various fractions and will keep a record similar to the middle chart. The horizontal lines indicate the 10 fractions. The first fraction will be a light mobile mixture of hydrocarbons whose average boiling point is about 227° F. The second is a slightly darker and slightly less mobile mixture of hydrocarbons whose average boiling point is about 295° F. The third cut again darker, heavier and less mobile, boiling point 369° F. The fourth cut still heavier and 460° F. boiling point. The fifth cut is about 530° F. boiling point. The remaining cuts are increasingly heavier, more viscous and darker in color and the residue in the still is a soft pitch. The chemist now asks what these ten fractions are chemically and he recognizes four groups of compounds in each fraction that the refiner may have to isolate or remove. First the coloring matter indicated in the diagram by the black area.

associate member, died February 7, 1912; George W. Melville honorary member, died March 17, 1912; H. W. Spangler, active member, died March 17, 1912.

Two social entertainments were held during the year. A reception and dance was held on May 10, 1912, the expenses of which were met by subscription, and a smoker on November 9, 1912, the expenses of which were defrayed from the Club funds. Both of these functions were well attended and successful in every way.

Attention is called to the excellent financial condition of the Club. While the net gain is less than in 1911, it is due to the fact that practically all of the uncollectable debts have been eliminated, leaving the accounts receivable of $3,792.83 a very good asset. Both the technical and financial status of the Club are better than at any other time in its history.

The Club is rapidly becoming the technical center of Philadelphia, as the Phila. Chapter Amer. Inst. Elec. Engineers, Phila. Chapter Amer. Soc. Mech. Engineers, Phila. Chapter American Chemical Society, Municipal Engineers of the City of Philadelphia, Delaware River Society of Marine Draftsmen and the Aero Club of Pennsylvania are holding meetings in the Club house. The members of the Engineers' Club are always welcome at any of the meetings of these societies, thus giving them an opportunity to come in contact with these various technical activities.

The following papers have been presented before the Club:

January 6—"Propulsive Machinery and Oil Fuel in the U. S. Naval Service." Capt. C. W. Dyson, U. S. N.

January 20—"Sub-aqueous Tunneling." Henry Japp.

January 27—"Dock Facilities in New York City; Present Facilities, Proposed Improvements and Extensions." W. J. Barney, Deputy Commissioner, Dept. of Docks, New York City.

February 3—Annual Address—"Ostwald's Energetics as a Moral Force and Law," and "Ives' Colorimeter and Color Photography." President Henry Hess.

February 10—"Hydraulic Gold Mining in British Columbia." Howard W. DuBois.

February 17—"The Development of Roentgenology." H. Clyd Snook.

March 2—"Smokeless Powder and High Explosives for Mili Uses." Lt. Col. Odus C. Horney, U. S. A.

March 16—"Stellar Evolution." Dr. John A. Brashear, of Pittsburgh, Pa.

April 6—"Recent Improvements in Street Pavements." George W. Tillson.

April 20—"The Gas Producer." H. E. Longwell, Consulting Engineer, Westinghouse Machine Co.

May 4—"The Engineer in His Relation to the City Plan." Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City.

May 18—"The Significance of 'The Middle Third,'" and "The Behavior of Cast Zinc Under Compression." John C. Trautwine, Jr.

June 1—"The Queen Lane Filtration Plant." S. M. Swaab.

September 21—"The importance of Meteorological Data in Engineering." George S. Bliss, Director, Climatological Service of Penna.

October 5—"The Exhibition for the Abatement of the Smoke Nuisance Held in London, Spring of 1912," George H. Perkins, of the Lowell Institute of Technology. "Methods and Means of Smoke Abatement," O. R. McBride, of the University of Pittsburgh.

October 19—"The Development of Separately Moulded Structural Concrete." C. D. Watson.

November 2—"Sanitary Protection of the Water Supplies Taken from the Great Lakes." Prof. G. C. Whipple.

November 16—"The Mechanics of the Aeroplane." Henry M. Neely.

December 7—"The Planning of City Streets." B. A. Haldeman, Engineer, General Plans Division, Survey Bureau, Philadelphia.

December 21—"Manufacture of Petroleum Products." F. C. Robinson, Chief Chemist, Atlantic Refining Company."

FINANCIAL REPORT

Statement of Assets and Liabilities as at December 31, 1912

ASSETS

Cash—Colonial Trust Co.—Active Account	$329.25	
Colonial Trust Co.—Interest Account	1,615.00	
In Office	549.09	
		$ 2,493.34
Accounts Receivable Members' Ledger		3,792.83

Inventory of Supplies on Hand

Wines and Liquors	267.37	
Cigars	174.15	
Fuel	26.12	
Restaurant Provisions	143.40	
House	50.43	
		661.47

Property

Building No. 1317 Spruce Street	72,850.00	
Furniture and Fixtures—House	9,181.69	
Furniture and Fixtures—Restaurant	1,330.84	
Library	2,100.00	
		85,462.53

Insurance

Perpetual on Club House	1,782.00	
Unexpired on Furniture	7.86	
		1,789.86

Miscellaneous

F. H. Stier, Treasurer		153.50
Total Assets		$94,353.53

Liabilities

Accounts Payable		$ 3,292.72
Bills Payable—Building Account	$8,100.00	
Bills Payable—Regular Account	1,500.00	
		9,600.00
First Mortgage Payable	40,000.00	
Second Mortgage Bonds	25,250.00	
		65,250.00
Accrued Interest—First Mortgage	1,080.00	
Accrued Interest—Second Mortgage Bonds	1,615.00	
		2,695.00
Link Belt Company, Second Mortgage Bond Account		529.58
Trustees of Bond Redemption Fund		36.20
Appropriation from Junior Section to Library Committee		203.49

Christmas Fund

Balance, January 1, 1912	$ 60.00
Contributions, December, 1912	285.50
Disbursements, December, 1912	

Capital Account

Surplus as at January 1, 1912	11,422.28	
Reserve for Redemption of Second Mortgage Bonds, Link Belt Co. Account	295.42	
	11,717.70	
Suspense Account, Uncollectable Accounts Previous to January 1, 1912	695.87	
	11,021.83	
Gain for year 1912 as per Statement of Income and Expense	1,625.71	
Surplus as at December 31, 1912		12,647.5
		$94,353.5

Statement of Income and Expense, Year Ending December 31, 1912.

Income

Dues—Net		$16,126.59
Initiation Fees		1,370.00

Publications

Advertising—Directory	$410.00	
Advertising—Proceedings	527.35	
Sales—Directory	2.50	
Sales—Proceedings	103.70	
		1,043.55

Miscellaneous

Badge Sales	26.00	
Excess and Deficiency of Cash	.50	
Interest on Deposits, Active Account	18.46	
Interest on Deposits, Interest Account	3.61	
Reprint Sales	27.00	
Telephone Receipts	162.28	
		237.85

Club House Business

Billiards and Pool Sales	219.62		
Cigar Sales	2,419.10		
Lodging	3,684.73		
Rent of Meeting Room	334.00		
Restaurant Sales	9,152.08		
Wine Sales	1,329.09		
		17,138.62	
Total Income Year Ending December 31, 1912			$35,916.6

Expenses

Salaries and Wages

Manager's Salary, May 1 to Dec. 31		$1,200.00	
House Salaries and Wages		3,217.45	
Office Salaries		2,750.70	
Restaurant Salaries and Wages		4,574.22	
			$11,742.37

Expense

House Expense		1,137.91	
Office Expense		427.75	
Directors' Expense		20.25	
Library Expense		61.40	
			1,647.31

Publications

Directory Publishing		320.19	
Proceedings Publishing		1,076.67	
			1,396.86

Miscellaneous

Badge Purchases			13.55	
By-Laws Revision			53.30	
Entertainment Committee			167.50	
Fuel Purchases	$544.70			
Inventory Jan. 1, 1912	18.20			
		$562.90		
Inventory Dec. 31, 1912		26.12		
			536.78	
Gas and Electricity			1,189.68	
Insurance			51.00	
Meetings Committee			550.00	
Membership Committee			133.81	
Reprint Purchases			26.50	
State Tax on Bonds			101.00	
Taxes and Water Rent			943.00	
Telephone Expense			363.78	
Club Luncheons			354.00	
				4,483.90

Interest and Discount

Interest on First Mortgage	2,160.00	
Interest on Second Mortgage Bonds	1,262.50	
Interest on Building Fund Notes	425.81	
Discount on Notes	15.00	

CLUB HOUSE BUSINESS

Billiards and Pool Purchases	$ 28.74		
Cigar Purchases	2,027.25		
Wine Purchases	1,036.01		
		3,092.00	
Restaurant Expense	$ 835.41		
Restaurant Provision Purchases	7,303.82		
		8,139.23	
			$11,231.23

INVENTORY, DECEMBER 31, 1912

Cigars	$174.15	
Restaurant Provisions	143.40	
House Supplies	50.43	
Wines and Liqours	267.37	
		635.35

INVENTORY, DECEMBER 31, 1911

Cigars	$195.57			
Restaurant Provisions	103.19			
Wines and Liquors	262.51			
		561.27		
Deduct Increase in Inventory		74.08		
Expense of Club House Business			11,157.15	
Total Expense				34,290.90
Net Gain for Year 1912				$ 1,625.71

Respectfully submitted,
F. H. STIER, *Treasurer.*

Audited and found correct.

STOCKTON BATES, C. P. A.,
For Stockton Bates & Sons.

The following is the report of the Trustees of the Bond Redemption Fund:

Fifth Annual Report of the Trustees of the Bond Redemption Fund. Being a Statement of Business for the Year 1912.

RECEIPTS

1912		
January 1, Balance from 1911	$33.20	
January 1, Refund of Box Rent	3.00	
		$36.20

EXPENDITURES

October 17, Transferred to Treasurer of Club, Temporarily Closing Account $36.20

The Trustees hold no negotiable securities.

HENRY LEFFMANN,
EDWIN F. SMITH,
EDGAR MARBURG,
Trustees.

Respectfully submitted,
THE BOARD OF DIRECTORS,
HENRY HESS, *President.*
W. P. TAYLOR, *Secretary.*

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, January 4th, 1913

The meeting was called to order at 8:35 P. M., with 75 members and visitors in attendance. The minutes of the Business Meeting of December 21st were approved as printed in abstract.

Mr. E. M. Nichols announced that Mr. W. L. Plack had withdrawn his name as a candidate for President.

Mr. Morris Knowles presented the paper of the evening, entitled, "Wise Utilization of the Water Resources of Pennsylvania," which was discussed by Messrs. John C. Trautwine, Jr., and J. E. Gibson.

On motion of Mr. Trautwine a vote of thanks was extended to Mr. Knowles for his paper.

Business Meeting, January 18th, 1913

The meeting was called to order at 8:30 P. M., with 75 members and visitors in attendance. The minutes of the Regular Meeting of January 4th were approved as printed in abstract.

The following were reported as having been elected to membership by the Board of Directors at thei meeting of January 16th, 1913: Active, John A. Coyle and Walter Dalton; Associate, John C. Bartlett, Hen y Franz and George Wood; Junior, William F. Carson and W. A. Sloan.

Dr. George Otis Smith, Director of the U. S. Geological Survey, presented the paper of the evening, entitled "The Engineer's Interest in Public Land Questions," which was discussed by Messrs. W. F. Ballinger, E. M. Nichols, H. W. DuBois, Dr. H. M. Chance, Dr. Carl Hering, W. C. Furber, A. E. Lehman, John C. Parker, P. A. Maignen, R. G. Develin, H. C. Berry and S. M. Swaab.

On motion of Mr. Hutchinson a vote of thanks wa extended to Dr. Smith for his paper.

Thirty-Fourth Annual Meeting, February 1. 1913

The meeting was called to order at 8:45 P. M. by President He s, with 125 members and visitors in attendance. The minutes of the Business Meeting of January 18 were approved as printed in abstract. The Annual Report of the Board of Directors was presented and approved.

It was moved and unanimously carried that the next meet ng be made a Business Meeting, to discuss the question of revision of the Charter.

President Hess, after relinquishing the chair to Vice-President Mebus, delivered his farewell address.

The tellers announced that 150 legal ballots had been cast, and the following were elected as officers of the Club for 1913:

President, W. P. Taylor; Vice-President, S. M. Swaab; Secretary, E. E. Krauss; Treasurer, J. Reese Bailey; Directors, J. E. Gibson, Manton E. Hibbs, H. Clyde Snook, F. K. Worley.

Business Meeting, February 15, 1913

The meeting was called to order at 8:25 P. M., by President Taylor, with 98 members and visitors in attendance.

The following action of the Board of Directors, taken at their meeting on February 13, 1913, was reported:

Mr. Wm. Copeland Furber was unanimously elected to fill the vacancy in the Board of Directors caused by the election of Mr. S. M. Swaab to the Vice-Presidency.

The Secretary reported the following deaths:

Eugene E. Dunlap, elected to active membership December 7, 1907 who died January 16, 1913.

John Fritz, honorary member, elected May 4, 1901, who died Februa y 13, 1913.

On motion the President was instructed to appoint a committee to prepare a memoriam on the death of John Fritz, honorary member. The president appointed the following committee: John Birkinbine, Edwin F. Smith, Joseph T. Richards and J. Chester Wilson.

The Secretary announced the election by the Board of Directors at their meeting on February 13, 1913, of the following new members:

Active Members—C. Willis Adams, H. Bruce Armstrong, Horace C Dickey, Henry J. Edsall, Robert H. Fernald, Erskine Hazard, Walter S. Hine, Joseph A. MacLennan, Horace E. Rice, Coleman Sellers, Jr.; James Smith Watson, R. Wayne Wetherill.

Associate Members—Joseph W. Breen, Charles E. Coburn, J. Richard Jackson, Leslie S. McPherran, Richard G. Ward.

Junior Members—Charles D. Williams.

The question of the revision of the Charter was discussed and the following resolution unanimously adopted:

Resolved, That the Board of Directors be authorized to obtain a Charter, which, while preserving the intent of the present Charter, will eliminate its inconsistencies.

Mr. Manton E. Hibbs, active member, presented the paper of the evening, entitled "The Unwritten Law," which was discussed by Messrs. E. M. Nichols, W. C. Furber, W. F. Ballinger, E. Perrot, H. H. Quimby, John C. Trautwine, Jr. and D. E. Dallam, Chairman of the Legislative Committee of the Real Estate Brokers' Association.

Regular Meeting, March 1st, 1913

The meeting was called to order at 8:45 P. M. by Vice-President Swaab, with 80 members and visitors in attendance. The minutes of the meeting held on February 15th, 1913, were approved as printed in abstract.

Mr. Francis Donaldson, Chief Engineer, T. A. Gillespie Company, New York, N. Y., presented the paper of the evening, entitled, "The Sinking and Lining of Shafts," which was discussed by Messrs. Eli T. Conner, H. M. Chance, W. C. Furber and S. M. Swaab.

A vote of thanks was extended to Mr. Donaldson for his interesting paper.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

REGULAR MEETING, January 16th, 1913.—Present: President Hess, Vice-President Mebus, Directors Worley, Vogleson, Berry, the Secretary and the Treasurer. Dr. Henry Leffmann, Chairman of the Trustees of the Bond Redemption Fund, was present, upon request, in order to advise the Board relative to the establishing of a special sinking fund for bond redemption.

The Treasurer's Annual Report, certified to by the auditors, was read and approved.

The Secretary's report and the annual report of the Board of Directors were read and approved.

The following resignations were read and accepted: W. K. Martin, C. W. Simon, R. H. Klauder, C. D. Ehret, John Meigs, S. E. Fairchild, Jr., R. K. Sheppard, Philip L. Spalding, George L. Thompson, J. A. Colby, J. O. Clarke and A. J. Menocal.

Mr. E. M. Bassett was reinstated to membership as of July 1st, 1912.

On motion, the Secretary was instructed to draft a set of resolutions in regard to Mr. Hewitt's resignation, and transmit the same to Mr. Hewitt, with a letter.

Reports of the Publication Committee, House Committee, Library Committee and Committee on Public Relations were presented and approved.

The Membership Committee's report was read and approved, and the following were elected to membership:

Active: John A. Coyle and Walter Dalton.

Associate: John C. Bartlett, Henry Franz and George Wood.

Junior: William F. Carson and W. A. Sloan.

The report of the Business Manager was presented and approved.

The matter of legal quorum was reported by the special committee on this question, and the report was accepted and the Committee discharged with thanks. The entire matter was then referred to Mr. Mebus, with authorization to refer the same to a competent attorney for his advice as to the legality of the various questions raised, report to be made at the next Board meeting.

The Business Manager was authorized to negotiate a liability insurance with the firm of Hoskins and Howell, premium of $43.74 to be paid, covering a period of three years.

It was moved and carried that the Manager's contract be continued.

The Business Manager was instructed to secure, free of cost to the Club, except for the cost of installation, the loan of a meter for a month, to determine the Watt consumption of the pump.

Upon report from the Manager regarding Mr. B. J. Sullivan's account, the Treasurer was ordered to cancel Mr. Sullivan's account from the books and strike his name from the rolls.

It was moved and carried that the sum of $850.00 previously provided for (See minutes May 19, 1910) be increased, so that $500.00 in addition to the interest be applied for this purpose within the next three months.

Associate—Joseph W. Breen, Charles E. Coburn, J. Richard Jackson, Leslie S. McPherran, Richard G. Ward.

Junior—Charles D. Williams.

The resignations of E. H. Zieber and Stanley G. Child were accepted as of December 31, 1912.

The report of the Business Manager was read and the following action taken on the matters presented:

1. The Business Manager was authorized to dispose of the old typewriters and purchase a new one at a cost not to exceed the list price of $100.00, less whatever discount could be obtained.

2. It was decided that letters relative to delinquent accounts be sent out over the signature of the Treasurer, as in the past.

3. The Business Manager was authorized to act as Trustee of the Christmas Fund, which was deposited in the Western Savings Fund Society, under "J. M. Ritchie, Trustee."

4. The question of the papering and painting of the meeting room was referred to the House Committee.

The death of Mr. E. E. Dunlap was announced, and the Treasurer was ordered to strike off his dues for the first half of 1913.

Copy of a letter sent by Mr. Henry Hess to Prof. Ira N. Hollis, President of the Engineers' Club of Boston, was read and ratified by the Board; and, on motion, the Board extended the privileges of this Club to the Engineers' Club of Boston.

Mr. E. P. Haines and Mr. William Vollmer were transferred to non-resident membership as of January 1, 1913.

In view of the fact that the question of Revision of the Charter o: the securing of a new Charter is to be considered at the meeting of the Club on February 15th, the President appointed Messrs. Charles F. Mebus, S. M. Swaab and J. A. Vogleson to constitute a Committee to proceed with this matter along the lines adopted by the Club at the next meeting.

The Treasurer was instructed to prepare a list of delinquent accounts and present the same at the next meeting of the Board.

Regular Meeting, March 13, 1913.—Present: President Taylor, Vice-Presidents Plack, Mebus and Swaab, Directors Develin, Gilpin, Vogleson, Haldeman, Yarnall, Hibbs, Worley, the Secretary and the Treasurer.

The President appointed the following to serve on the Library Committee: F. N. Morton, A. L. Magilton.

Meetings Committee: W. C. Furber.

The Chairmen of the Publication-Advertising Committee and By-Laws Committee were authorized to make appointments to fill the vacancies in their Committees.

The Board elected the following members to serve as Tellers for the year 1913: E. J. Dauner, L. H. Kenney, G. Wise.

The Treasurer reported a net gain to March 1st of $1,038.11, as compared with $68.19 for the same period of 1912.

The resignation of W. J. Taggart was presented and accepted.

THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

OFFICERS FOR 1913

MEETINGS

Annual Meeting—1st Saturday of February, at 8:15 P. M.

Stated Meetings—1st and 3d Saturdays of each month, at 8:15 P. M., except between the fourteenth days of June and September.

Business Meetings—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

to him by the community as a whole. It is well that we should be reminded of the absurdity of such notions; for it is they which, more than anything else, retard our progress toward civilization. Owners of "property" (really tax-collectors, though calling themselves "tax-*payers*") oppose every effort to increase their real wealth by means of drafts upon their private or fictitious wealth; and we may be sure that Mr. Knowles's proposed scheme of river regulation for the Pittsburgh district, will not be put through without encountering their lively opposition, although its construction costing, if I remember rightly, not much more than the mischief wrought by one severe flood, will eliminate all future floods. Such is the wisdom of our wise men!

Mr. Knowles was disposed to admit that this dream of a worthy conservation of our water-sources was impossible of realization. If he will qualify this by adding "within the next few years," I must reluctantly agree with him. It is a law of social, as of physical, mechanics, that the movements of great masses cannot be suddenly and greatly changed without risk of damage somewhere. Any attempt to grasp the blessing prematurely could result only in lamentable failure; but the change is coming about, quite as quickly as our conservative natures can stand it; and any one who, in imagination, will glance along the curve of our progress in this direction during the last hundred, fifty, twenty-five, ten, two years, must recognize the stupendousness of the change already accomplished, and must see that its complete realization, during the lives of some now living, is as inevitable as its immediate accomplishment is impossible.

The alienation of so large a part of the nation's land is not wholly a matter of regret. The winning of the West necessitated terms of land transfer that today may seem far too generous. The fact that must not be overlooked, both as we judge the past and plan for the future, is that conditions have changed. The shrinkage of the national domain has naturally been coincident with the Nation's development in all lines of industry. The Western prairie has become the world's granary, and what were once public lands are contributing to their private and corporate owners no small proportion of the world's output of metals and of mineral fuels. With the national growth on this scale, there has come necessarily a general increase in land values and the problem of finding land for the settler is already looming large on the horizon. Exploration and exploitation must now be followed by intensive utilization. With the most and the best of the Nation's land already alienated, the task is to put to its best use what remains.

Engineering in its broadest sense stands for increased efficiency and wise utilization. The engineer's relation to the public lands and the nation's resources is simply that of a constructive interest in their best utilization. The public land problem of today, whether we view it from the standpoint of a Federal officer or of a private engineer, is one of administration and of legislation. Your interest like mine in the matter is to have the existing public land statutes wisely and fairly administered and to secure the enactment of other laws that recognize present day needs. To enable your engineers to do your part in securing the highest use of the great resources now in public ownership, you need and deserve definite and prompt administration of the public lands—administration that is not a paper administration, but one based upon consideration of the same physical facts that you must determine and coördinate in your plans for development and use. So too, our interest as American citizens, you as the technical adviser of Capital and its active representatives in the great projects for industrial progress and others of us as the technical advisers of the Nation's executive and the people's representatives, in these same plans for national development, should lead us to unite in securing legislation adapted to promote the wisest use of the nation's resources. In the widest sense our interests are the same, because our purpose should be identical, the greatest industrial development of the country, but a development that will promote citizenship as well as turn the wheels of industry.

physical conditions giving value to those lands and controlling their highest utilization.

Not only is the engineer interested in the right classification of land in order that he may not be an accessory or instrument of fraudulent practice, but he does not want to be connected with an engineering project that involves large economic waste. Your professional code opposes your contributing your technical skill to a mining development or an irrigation scheme, or a hydro-electric installation whose only possible purpose is the taking of a promoter's profits before that day of reckoning when the balance is struck between cost and value. Therefore, you and I are alike interested in 'knowing the facts of land-classification that will prevent the construction of reservoirs and canals for a Carey Act project where the water supply is insufficient or the soil unsuited to irrigation. We will agree that power-sites should be used as such and not as homesteads; that mineral lands should be acquired by mining men for mine-development and not by non-resident capitalists for the timber value; that irrigable lands should be irrigated and not dry-farmed; and that reservoir sites should be used to promote irrigation or power development, and not as cattle ranches.

The need of a definite and reliable classification of the public lands is self-evident, and the recognition of its value is no recent discovery, yet only within the past few years has scientific classification of our public lands been given a definite place in the administration of the national domain. It is true that in 1879, "classification of the public lands" was made the first of the statutory functions of the United States Geological Survey then created; but this duty was for over twenty-five years subordinated to the general task of investigating the public domain and its resources. Again in 1888, the Director of the same federal service was entrusted with the segregation of the irrigable lands and the selection of reservoir sites, but this irrigation survey later narrowed itself into the specific work of the Reclamation Service under the Reclamation Act of 1902, while the functions of stream measurement and investigation of water resources continued by the Geological Survey only very recently began to be recognized as a necessary basis for public land classification and administration.

The present system of land-classification, its contribution to public land administration, and its relation to the engineering

Resurvey T. 19 N., R. 105 W. of the Sixth P.M., Wyoming

Coal land price
not fixed because
General Land Office
records show it to be
in private ownership

	Acres
Coal, priced	13,819
Coal, not priced	6,634
Non coal	2,775
Total	23,208

As given	$1,773,289
Minimum	276,381

Replacing plat
transmitted by
Geological Survey
September 8, 1909

I classify and
price the land
in this township

Large figures
give price in
dollars per acre

U.S. Geological Survey
May 28, 1910

**Coal land within
15-mile limit**

Naturally, the fields of the irrigation and power engineers overlap, especially in view of the fact that the 1891 irrigation law conveys a grant to the public lands needed for an irrigation right-of-way, while under the 1901 power act only a revocable permit for power development can be secured. The natural tendency, therefore, has been to call practically every proposed development an irrigation project, even where the "irrigation" company is discovered to have offered to contract for the sale of all the hydro-electric power developed for long distance transmission, but to have perfected no plans for contractual relations with owners of irrigable land in the vicinity.

The withdrawal of power-sites by the Federal Government to the extent of nearly two million acres has not been actuated by any desire to arrest the industrial development of the West, but these executive acts have the constructive purpose of insuring the highest use of these most valuable portions of the public domain. The conflict in the use of our public land streams for municipal, irrigation, and power purposes is fully recognized, and one of the Survey engineers has recently published a discussion of these relative values. Not only the dominant temporary use of a particular stream, but its highest ultimate utilization must be considered. By this procedure the irrigation use will be given the preference in one case, the power development in another, while in a third the stream may be harnessed so as to serve effectively both uses. It is readily appreciated by an engineer that the complexity of the problem only stimulates the desire to attain the proper solution and make the administrative action on a pending application such as to aid highest utilization.

Here again, unfortunately, the executive officer at Washington often finds his hand tied, though his eyes are open to the needs of the situation. The statutes that control give too little discretionary power and demand revision to meet the business requirements of today. Thus another large opportunity presents itself to the engineers for coöperation in the securing of legislation that will afford capital the desired measure of safety in its investments and at the same time safeguard the public against both wasteful competition and unregulated monopoly. No one can bring to this difficult task a better equipment of training and experience than the engineers of the country, and a lobby at Washington of engineers with high ideals of profession and citizenship would be a power for good.

the needs of the West. In the case of the representatives of the West, too often there is lack of agreement as to what requirements of the East should be met. I think there is some agreement at the present time along the line of revision of our mineral laws; I think the consensus of opinion is that there should be some such revision of our land laws, and I think what is needed more than anything else is, what I have already indicated, concerted action on the part of the various engineering bodies of the country looking to a movement whereby not only will the courts be stimulated to make the needed requirements, but, in making those amendments, will be guided by your knowledge of what is needed. Congress in quite a few cases has acted quite promptly. The withdrawal of 1910 provides for the control of these tracts of land very plainly, with the purpose of withholding land from proper entry pending the enactment of a law which will provide for their proper entry and their alienation, or, in many cases, their leases under proper terms and conditions. I think progress is being made, but it is rather slow.

Mr. Ballinger.—Has there been any objection on the part of the Government to preparing a bill which would amend those conditions?

Dr. Smith.—In that connection I may say that within the past five years we have drafted bills almost without end, and such bills have been introduced, but no action has been taken on them, largely, I think, because of considerable objection to the leasing principle; but that objection is fast passing away in the West. In the case of oil lands, some of the men on the ground see no disadvantage in leasing from Uncle Sam, as contrasted with leasing from the man who got it from Uncle Sam for nothing.

There is one matter that is pending even now, a draft of a leasing law for potash deposits. It is now before the Secretary of the Interior for his consideration. There are certain interests that are very much interested in getting some method of working the deposits of Searles Lake for instance, in Southern California, and it looks to some of us as if the different interests might get together, and if they do, and all push together, the probable result would be that Congress would pass the law. In other words such a thing as that can be done very speedily if everybody is pushing on the same end of the proposition; it is when they are divided and pushing on opposite ends that nothing is done.

Mr. E. M. Nichols.—Can you state relatively the value of the potash deposits of Searles Lake in comparison with the German deposits of phosphates and potash?

Dr. Smith.—I think I would be going pretty far if I made such a comparison, but I believe there is a large quantity of potash that is available, and some engineers who have investigated, believe that it can be extracted at a cost that will enable the product to reach the Mississippi Valley, for instance, and compete with the German product, not at the present prices of the German product, but at the price to which the German producers, it is believed, can lower their product. Of course, cheaper potash ought to reduce the high cost of living.

Mr. Nichols.—What are the transportation difficulties in getting to the Mississippi Valley?

out a circular letter in order to get the ideas of representative people on this matter and I understood from Mr. Winchell that the replies were practically unanimous to the effect that the Apex Law should be done away with. There seems to be a consensus of opinion, but an absence of action.

In regard to the other laws, I do not know that there is any similar concerted movement. I think we would make a mistake if we tried to do too much with any one law. We have made the placer law a sort of panacea. When oil was discovered in California, we said we will pass a law to fit the case, and we simply applied the placer law to the case of oil. When placer gold is discovered, it is discovered in many cases on the surface, whereas the discovery of oil necessitates the work of months and the expenditure of tens of thousands of dollars, and during that period in which money was being expended freely, there exists not only the possibility of jumping the claim by putting up other paper locations, but there was also the possibility of a man with more capital and a better rig coming in and drilling at a faster rate, and striking oil first; he might pump it all away from the first man, and what would be considered the original man on the ground was absolutely without recourse. I think that is the trouble with trying to do too much with one law.

Now there was asked the question, why could we not apply the law for potash to phosphate as well? Well, phosphate could better be compared to coal in its occurrence. The amount of area that a man should be given for potash is quite different to the area a man should be given for phosphate. The trouble with such an occurrence is, for instance at Searles Lake it is only 20 feet below the surface, and you get the brines all ready to pump it out.

Mr. Nichols.—Isn't it largely a mere shovel proposition?

Dr. Smith.—No, it is a pumping proposition, and if a man wants to get it out, he needs control of a large part of that concentration basin. As a Philadelphia man says, you need to have only one acre, and you can dig a hole and pump the whole thing dry for a mile around. I think it was the same Philadelphian who said you only need one straw to drain a mint-julep.

Mr. Dubois.—Is there any basis for the remarks as to a change in the Apex law? The fact would seem pertinent that a great majority of the Members of Congress are lawyers, and are therefore interested to see that the right kind of legislation is going on. Is there any real basis for getting away from the Apex law?

Dr. Smith.—I think I can quote one ex-representative from the State of Nevada, who wrote me that he saw I had come out against the Apex law. He said the Apex law has been the salvation of the Western lawyer, and if you do away with it, the miners will get all the money and the lawyers none.

Dr. Hering.—When the land grants were made to the Western railroads, did they exclude or include mining rights?

Dr. Smith.—Those grants excluded mining rights, with the exception of coal and iron, which should be considered as not a mineral for the purpose of this act, it being considered that coal and iron were essential to the construction and operation of the railroads, so that the Northern Pacific and the Union Pacific

the purposes of the Navy there has been a permanent reserve created, including some of the land that is contested in the courts between the Government and the Southern Pacific Railroad.

DR. HERING.—Is it known what the value of these coal lands are in Alaska, about which there has been great dispute in the last two years?

DR. SMITH.—That question is yet in dispute. Take the lands in the Bering River field, the lands that were claimed by the Cunningham group of claimants; there is coal in large quantity there, but the ground is badly faulted and disturbed, and it is a matter that needs very careful engineering and exploration to determine just how valuable those coals are. The quantity is there and the coals must be good, but the costs, I believe, are going to be greater than some of the magazine articles indicate.

While we have been discussing coal, the California oil has taken the full market for the Pacific Coast, and I believe the California oil will dominate the Pacific Coast market.

DR. HERING.—Have the people any rights to the oil lands in California?

DR. SMITH.—There are large areas that have not been touched. No one has been able to enter that land, at any rate since the withdrawals of July, 1910. All over the fields there are unpatented lands, but even there it is a question of what is the range of pumping. I thought that the oil under those lands was a very mobile affair and it could be compared to that mint-julep proposition. But after being on the ground and hearing the testimony of the most experienced drillers, it looks as if it was difficult to pump your neighbor's land. You can take the gas pressure away from him, but as to pumping dry his land at some distance from your wells, it would take some time to do that. Take Derrick Avenue at Coalinga, it was found that some of the wells on that Avenue at no great distance from where wells had been pumping for many months, the later wells had almost as good a flow, but they were pumping wells from the start. There was no gas pressure there; the gas pressure had been taken by the earlier well, but they were good pumping wells and they kept up, and apparently the land on one side was holding as well as on the other.

MR. LEHMAN.—How does that coal in Alaska compare with our coal here?

DR. SMITH.—You could compare it with the Pittsburgh or Pocohontas coal. When we were being investigated I could have given you the B. T. U.'s of these coals, but we have forgotten some things that we were primed with. I am speaking of the Bering River and the Mantanuska coals; those are the two most promising. The fields are not so large as some of the fields in the States. Whether it is a marketable fuel at this time I do not know, it is a question of depth. The demand for coal on the Pacific Coast is not very great. It would take only a few of your good sized Pennsylvania mines to meet the whole demand of the Pacific Coast. You see we have coal from Australia coming in there, and those coals come in under conditions that are not dependent upon the local coal market. Ships come in there with coal for ballast. At the time the Survey made a review of the coal resources o the United States, some ten years ago, I summarized the conditions on the Pacific Coast, as I was working then in the State of Wash-

are not six months old yet. It is all too short a time in which to take up a proposition of that sort.

MR. NICHOLS.—Are you doing any photographic survey work in the United States?

DR. SMITH.—No, not in the United States proper, only in Alaska.

. . . .

DR. HERING.—Is the boundary line located now all the way to the Arctic Ocean?

DR. SMITH.—Yes, I believe it is.

DR. HERING.—Is the Alaska steaming coal as good as the Pennsylvania coal?

DR. SMITH.—I think it is.

DR. HERING.—How would the coal fields of Australia and China compare with the coal fields of the other countries of the world?

DR. SMITH.—I do not think we know enough about China to make any comparison.

MR. NICHOLS.—Is there any restriction on the exportation of coal from Great Britain?

DR. SMITH.—I think there has been recently. I was talking with the Director of the British Survey some years ago—I knew that he had been a member of the Royal Commission to take up the question of coal supply, and I asked him if his Commission made any recommendation that the export of coal be prohibited. He said the Commission did consider it, but they did not want to make any recommendation that might be laughed at by future generations. He said that when the English army depended upon bows and arrows for its fighting material, the cry went up that yew wood was giving out and there would soon be insufficient yew to make the bows out of in England, while Germany had immense forests of yew, and it was predicted that when the supply in England was exhausted, the Germans might come over and take possession of the island. Likewise, the Admiral who succeeded Nelson decided that the supply of oak timber would soon be expended and there would not be enough to build any more ships of war, and when he was an old man he would go about with a pocket full of acorns and a long walking stick. He would make a hole in the ground with the end of his stick and plant an acorn wherever he could. Some of those oak trees are now ready to furnish timber for the battleships! Therefore, bearing in mind, I suppose, some of these predictions of history, the Commission did not make any recommendation regarding coal exports. They realized, moreover, that it might interfere in a serious way with the whole complex arrangement of manufactures and commerce.

Q. (Mr. ?).—Would you discuss briefly the prospects of the use of the oil shales in the middle West?

DR. SMITH.—Similar oil shales are and have been used for a long time in Scotland for making a kind of mineral oil, but I do not think the time has come for their profitable use, when we have crude oil selling as low as it is in some parts of the country.

MANHATTAN BUREAU OF BUILDING INSPECTION. 1902–1911.

Population of Manhattan, 2,331,542.
Area of Manhattan, 22 square miles.
Dwellings in Manhattan (1910), 75, 410.

BUILDINGS TEN STORIES AND OVER (1912)

Stories.	Buildings.
10	179
11	181
12	191
13	389
14	44
15	27
16	28
17	31
18	13
19	13
20	12
21	15
22	11
23	3
24	4
26	4
27	2
31	1
32	1
33	3
38	1
41	1
45	1
55	1
Total	1156

I have merely suggested the workings of the "Unwritten Law." Let the makers of our laws differentiate between laws and regulations, making public safety as a whole the object of the former, and structural strength by the bureau the aim of the latter: be wary of clauses giving present structure a long lease of life; give a better classification of buildings, pay more liberal appropriation to bureaus, pay more attention to exits, and place the fire drill in its right position, and you will have gone a long way to curb what I have termed the "Unwritten Law."

MOTOR VEHICLES

About fifteen years ago the automobile made its first appearance upon the streets of our cities as a practicable pleasure vehicle. Today over one million machines are hurrying and scurrying through the highways and byways of our vast land. As a pleasure vehicle, the automobile has practically displaced the horse-drawn carriage, not because it is a cheaper form of transportation, but because one can go farther and faster and have more fun. While the large number of pleasure cars has not been without some effect on passenger transportation, especially intra-mural and suburban, this has been small in comparison with the volume of the business, and merits no further consideration.

Within a very few years, however, the self-propelled vehicle has been applied to uses other than pleasure, and promises to become a real factor in the transportation problem. I refer to the rapidly increasing adaptation of the motor truck to commercial uses, which greets one on all sides in and about our larger cities. The mere fact that progressive merchants, manufacturers and contractors, to whom the question of dollars and cents is of paramount importance, are committing themselves to motor trucks for delivery and haulage purposes is sufficient evidence of the economical advantages over horsedrawn vehicles.

Motor trucks are now manufactured with capacities up to 10 tons, and by suitable modifications of their bodies are adapted to a wide range of special services. Greater loads and greater speeds have established conclusively the economy of the motor as compared with the team for all classes of city and suburban delivery where good roads are available. Under favorable conditions a heavy truck will negotiate 300 to 400 ton miles per day, as much as 7 to 10 teams of horses. A prominent maker of motor trucks claims a cost of 4 ½ cents per ton mile as compared with 11 cents for teaming.

Although motor truck transportation is still in its infancy, it has already assumed formidable proportions. Many manufacturers of pleasure cars have added commercial cars as a branch of their business, while other concerns limit their output entirely to this class, and all are prospering. Aside from its already established advantages as a means for delivery and haulage within cities and their immediate suburbs, there are other possibilities

its effect inappreciable at a distance of 1,000 feet. In a channel 770 feet wide and 12 feet deep, while running at 11 miles per hour the swell at the shore measured 5.5 feet from hollow to crest. Ordinarily the provision of purely artificial channels of adequate dimensions to permit of free and easy navigation will involve so large a capital outlay as to make economical returns without a very large volume of traffic. Comparisons of rail and water rates are frequently misleading for the reason that no account is taken of the capital charges against the cost of channel improvements when these improvements are made at the expense of National or State Governments. A correct analysis of transportation charges on existing water routes in which capital and operating charges are included will reveal the fact that water rates are often higher than railroad rates. Government expenditures on water routes are not infrequently supported by the plea that even if they do not develop a traffic that will show returns, they serve the public indirectly by acting as a corrective on exorbitant railroad charges. Granting this to be true in certain cases, it would appear that a more certain and less expensive method for correcting railroad rates might be devised.

In Europe inland water transportation makes a better showing than in the United States, and water-borne traffic is still a factor in internal commerce. This is accounted for, partly at least, by the fact that in European countries centers of population and of industry were located on available water routes long before the advent of the railroads, and that trade accustomed itself to this mode of transportation. When the railroads made their appearance in the United States much of the country was still an undeveloped wilderness. The new agent of transportation with its flexibility and independence of topographical conditions permitted the establishment of towns and industries without reference to water routes, and at points where water transportation is economically impossible. The shorter hauls and denser populations of European countries also favor water transportation. Germany, with 200,000 square miles and 65,000,000 people has one mile of railroad for each 1,600 population, as against one mile for each 400 in the United States. But even in Europe many of the old time canals are failing to show economic returns and are experiencing a declining traffic.

The fact that haulage charges are admittedly lower by water

been accompanied by a continued increase in the size of the lake boats and a reduction in freight rates. In 1859, the largest vessels averaged 700 tons net register, with the 12-foot draft available. In 1890, when the 16-foot navigation had been finished, the average net registered tonnage of the large vessels had grown to 1,500 tons. With the present 20-foot navigation the largest vessels carry cargoes of 8,000 to 10,000 tons. In 1890, the average lake freight rate was 1.5 mills per ton mile; in 1912 it was reported at .67 mill per ton mile. These rates, of course, do not include capital charges, on account of improvements of the waterways, which are a gift of the Government. So large is the traffic, however, that the inclusion of capital charges would not increase the freight rate materially.

The astonishingly low freight rate on the Great Lakes is the result not only of the potential economy of water transportation, but also to the development of special transportation facilities for a more or less special transportation service. The bulk of the freight consists of ore, coal and grain, commodities which can be quickly loaded and unloaded, thus reducing terminal charges. Coal and ore chutes, car unloaders, hoisting and conveying machinery and numerous hatchways enable the lake carriers to take on or discharge cargoes with remarkable speed, so that little time is lost in port. Such a combination of favorable conditions as obtain in the transportation business of the Great Lakes is, of course, unusual, and the low freight rates are in consequence exceptional.

The mere existence of a natural water route is of itself no guarantee of an economical transportation service. Unless the route has traffic possibilities, it cannot show economic returns. The great volume of the traffic of the United States has for years moved, and still moves, on east and west lines. While the traffic of the Great Lakes is increasing yearly, that of the Mississippi River and its tributaries is at a standstill. Aside from obvious physical difficulties, due to floods and shifting channels, the direction of the river crosses the main arteries of commerce, and this of itself is a sufficient handicap to prevent the realization of the of the waterways enthusiasts, who for years have been a 14-foot channel from the Lakes to the Gulf, with steamers tied to the banks. Fortunately, wiser cour to have prevailed, and the danger of the Government

in all parts of the world. Staggering sums are being expended at the present time to provide accommodations for the large ships now in use, and one needs only to consider the vast engineering works at Bremen, Hamburg, Liverpool, London, Havre, New York, Buenos Aires, and other world ports to realize the obligations that have been imposed by the increased dimensions of vessels and the growth of the world's traffic.

It is not only in the matter of deeper and more commodious channels required, but also in the enlarged port facilities that the very large ships of today are giving concern. The piers, dry docks, wet docks, and quay walls to accommodate these ocean monsters are exceedingly costly, and must eventually operate to limit growth in size if consideration be given to economical returns. Hitherto the extraordinary growth of the world's commerce has enabled costly port works to be carried out under conditions which have either actually shown economic returns or have been considered justified by governments on the ground of general benefits, regardless of returns on capital expenditures. If, however, ships continue to increase at the present rate, it is certain that a point will be reached beyond which port and governmental authorities can not go in the matter of providing accommodations. It may well be questioned whether we have not already reached a point where capital charges for channel and port improvements do not exceed the economies resulting from carriage in large ships.

As a matter of fact, the costly harbor accommodations now being provided serve relatively few ships, engaged in special service and plying between great centers of commerce and population. The great bulk of the world's carrying trade is still carried in ships of relatively modest dimensions, and not requiring excessive channel depths. An examination of the British register of merchant vessels for 1910 shows out of a total of 11,500 steel ships above 100 tons gross register, only 328 exceeding 7,000 tons, and only 20 exceeding 15,000 tons. It is these very few large vessels, carrying an insignificant part of the world's commerce, which has forced the huge expenditures which are now being undertaken for port improvements. It looks very much like a case of the tail wagging the dog.

The fact that we have the very large and fast steamers on our hands must be taken as prima facie evidence that their owners expect economical returns, either directly or indirectly. It must

for the largest vessels now afloat or building, and leaves some margin for future increase.

In this country it is the policy of the National Government to provide the necessary approach channels to ocean ports and to fix the harbor lines beyond which encroachments by riparian owners is forbidden in the interests of navigation. Until very recently the development of port facilities has been left to the several riparian owners without any central or general control. In Europe and elsewhere a different policy generally prevails, the administration of the port as a whole, including the provision and maintenance of approach channels, being in the hands of a single body, a Board or Commission invested with the needful legal authority and deriving its funds from the sale of bonds, aided by contributions from the States and municipalities. Charges are made for the facilities offered, and the revenues so derived are applied to the maintenance and improvement of the port and to pay capital charges.

The principal requirements of a successful ocean port are:

1. An approach channel of ample dimensions.
2. Ample dockage facilities.
3. Warehouse space.
4. Freight handling machinery.
5. Facilities for coaling and repairs.
6. Railroad connections.
7. A hinterland affording traffic possibilities.
8. Low port charges.
9. A unit control for the management and development of the port facilities.

Port administration as heretofore practiced in the United States has been characterized by haphazard methods and a general lack of any definite policy looking to future growth and development, Out of some 50 principal coast and lake harbors, only two, San Francisco and New Orleans, are at present adequately administered by a single authority operating under State laws. While other ports, like Boston, Philadelphia and Baltimore, have duly legalized port authorities, their usefulness is greatly curtailed by the fact that the greater part of the water front property is owned and controlled by private and corporate interests, mainly the railroads. Where such conditions prevail it is too much to hope that these interests will voluntarily improve their property in

PAPER No. 1126

THE PANAMA CANAL AS IT RELATES TO THE TREATIES

BY REAR ADMIRAL C. M. CHESTER (retired).

Read April 5, 1913

The most important question before the American people today is the Panama Canal in its relation to the foreign policy of the United States. We have, by the action of our Government, under the Act of Congress approved August 24th, 1912, in exempting our coasting trade from canal tolls, raised an issue of honor with the nation with which we are most closely connected by ties of interests and race. Honor should come before interests, and the subject requires the most careful treatment before the people commit themselves to a policy, which is not only opposed by England, but by all other nations as well, and which, if persisted in, will surely lower the moral standing of our country in the eyes of the world.

FOUNDATION OF THE TREATIES

It should be remembered that, at the time of the execution of the Clayton-Bulwer Treaty, England claimed sovereignty over a good part of Central America, including the Mosquito Coast, British Honduras and the Bay Islands. The government of the United States, says a good authority, alarmed at the preponderance of British influence in Central America, cast about for a means of counteracting it.

To oust England from her strong position by force was felt to be too grave an undertaking, even were the United States disposed to attempt it. But the American statesmen of the day were, as a rule, only intent in securing a free transit across the isthmus not under the exclusive control of any European nation. They resolved therefore upon a peaceful and conciliatory policy; if England could not be got rid of, she might consent to act in conjunction

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS.

REGULAR MEETING OF THE BOARD OF DIRECTORS, APRIL 17, 1913.

The meeting was called to order by President Taylor at 8:15 P. M., with Vice-Presidents Plack, Mebus and Swaab, Directors Develin, Gilpin, Vogleson, Berry, Haldeman, Furber, Gibson, Hibbs and the Secretary in attendance.

The minutes of the Regular Meeting of March 13, were read and approved, and the minutes of the Special Meeting held March 17 were also read and approved.

The Secretary's report was read, and the following action taken with reference thereto: The resignation of Mr. H. B. Bryans was accepted as of July 1, 1913, and his dues for the remainder of the year charged off; the resignation of Mr. Michael Monaghan was accepted as of December 31, 1912, and his dues for the year 1913 charged off; the resignation of Mr. Fred. G. Thorn, Jr., was accepted as of December 31, 1912, and his dues for the year 1913 charged off; and the resignation of Mr. Howard B. Green was accepted and his unpaid dues charged off.

The Secretary was instructed to communicate with the American Society of Marine Draftsmen, Philadelphia Chapter, and advise them that the Board finds that it cannot extend the courtesies of their meetings to them, as it would conflict with the By-Laws.

The Treasurer's report was presented and approved.

The Treasurer was instructed to send a statement of Mr. H. R. Wilkinson's delinquent account, amounting to $70.00, and advise him that if this amount were paid, his resignation would be accepted.

The House Committee's report was read and approved.

The Membership Committee's report was presented and Messrs. Eli T. Conner, Carleton E. Davis and John Mellor were elected to Active Membership, and Messrs. A. C. Fisler and Karl Nibecker were transferred from Junior to Active Membership.

The report of the Meetings Committee was read and approved.

The reports of the Publication-Advertising and Library Committees were read and approved.

The Library Committee was instructed to send a copy of the proposed list of books for the library to each member of the Board of Directors, asking them to advise the Committee as to additions or alterations to this list.

The report of the Committee on Public Relations was read and approved.

The Business Manager's report was read and approved.

The proposed revision of the By-Laws as compiled by the Committee on Revision on By-Laws was presented to the Board and certain changes ordered to be made, and this revised copy ordered to be presented at the Regular Meeting of the Club on Saturday, April 19th.

ABSTRACT OF MINUTES OF THE

BUSINESS MEETING, MARCH 15, 1913

The meeting was called to order at 8:30 P. M. by Presi members and visitors in attendance. The minutes of th March 1, were approved as printed in abstract.

The report of the Committee to prepare a memoriam Fritz, Honorary Member, was presented by Mr J. Che unanimously adopted.

The President announced the death on March 11, 1913, o Member, elected to membership October 17, 1908; and th tore at its meeting on March 13, had instructed the Publ prepare a memoriam on the death of Mr. Burns, to be inc ceedings.

The Secretary reported the election of the following me of the Board of Directors on March 13, 1913: Active—C. E C. Fish, William C. Greany, Donald B. Heilman, John I Rock; Associate—Frank B. Johnston, Jacob T. Swartz; Demmert, William N. Edwards, Erle C. Herman, Charles Downs, Carl A. Woerwag.

Mr. Hermann V. Schreiber, of Sellers and Rippey, Cons sented the paper of the evening, entitled, "The Design an Hydro-Electric Plant at Estacada, Oregon," which was C. P. Birkinbine, Harrison Souder, G. L. Watters, Emile C kinbine, and others.

A unanimous vote of thanks was extended Mr. Schreib paper.

REGULAR MEETING, APRIL 5, 1913.

The meeting was called to order at 8.30 P. M. by Vice-I 132 members and visitors in attendance The minutes of of March 16, 1913, were approved as printed in abstract.

The paper of the evening, entitled "The Panama Cana Treaties" was presented by Rear Admiral C. M. Chester, discussed by Messrs. Wm. Easby, Jr., Major Gillette, H. M. Chance, John C. Parker, W. Ballinger, O. C. Schmidt Jr., and P. A. Maignen.

A vote of thanks was extended to Admiral Chester for t paper.

The following motion was presented by Mr. S. M. Swaab and unanimou adopted:

"Resolved, that all past actions of the Club and of the Board of Directors and the same are herewith ratified."

The paper of the evening, entitled, "Some Aspects of the Subject of Transp tation," was presented by Lt. Col. J. E. Kuhn, U. S. A., Corps of Engineers.

A unanimous vote of thanks was extended Col. Kuhn for the presentatio his valuable paper.

Business Meeting, May 7, 1913.

The meeting was called to order by Vice President Plack at 8:30 P. M., w 63 members and visitors in attendance.

The minutes of meeting held May 3, 1913, were approved as printed in abstra

The Secretary announced that the Board of Directors, at their meeting May 15th, had elected to Junior Membership F. Van Buren Connell and Rich B. Ferris.

The Committee on Nominations for the coming year, as elected by the Bo of Directors, was announced, as follows: H. E. Ehlers, Chairman; Joseph Wagner, F. H. Stier, Carl Hering, E. M. Nichols, Thomas McBride and Geo T. Gwilliam. This list was laid over until the meeting of June 7th for alterat or acceptance by the Club.

The amendments to the By-Laws were discussed, amended, and ordered s to the members for ballot.

The paper of the evening, entitled, "Suction Gas Producer Pumping Eng vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine, G ing Cost of Operation and Fixed Charges Based upon Five Years' Operating perience," was presented by Mr. J. E. Gibson and discussed by Messrs. Led Fernald, McBride, Dallett, Chance, A. C. Wood, Wm. T. Price and Gibson.

SOME INTERESTING FACTS ABOUT PHILADELPHIA

Population (census, 1910) 1,549,008.
Area, 129 square miles.
Lat. of City Hall
Long. " "

Jan.	Feb.	March								Nov.	Dec.	Annual
32.4	33.1	40.5								45.0	35.4	54.

Normal Maximum Temperatures

39.4	40.3	48.3	55.9	66.3	74.3	78.4	82.2	76.3	64.6	52.4	42.3

29.1

3.06 41.51

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MILES OF SEWERS

Branch sewers	891.16
Main sewers	190.072
Private sewers	167.096
Total	1248.328

Course of North Broad Street—N. 9° 31′ 23.70″ E.
Course of South Broad Street—S. 9° 30′ 24.18″ W.
Course of East Market Street—S. 80° 47′ 54.52″ E.
Course of West Market Street—N. 80° 48′ 24.70″ W.
The following standards of measurement are used:
Horizontal—100 feet City standard equal 100.25 feet U. S. Standard.
Vertical—U. S. standard is used.
The City datum is 5.56′ above mean tide Sandy Hook.

Philadelphia owns or controls 5,129 acres of ground for park purposes, and 1,229 acres plotted on the City Plan, but not yet condemned for park purpo

PAPER NO. 1129

THE SINKING AND LINING OF SHAFTS

BY FRANCIS DONALDSON

Read March 1, 1913

When mining was begun in America timber was cheap and plentiful, the deposits of virgin coal and ore were widely distributed and could be reached at no great depths, and the development of the rectangular timbered shaft was the natural result. Nowadays shafts are becoming deeper, mining installations more and more

FIG. 1.

expensive and mining men are beginning to think they could possibly get better results by a partial return to European methods, and by the use of permanent linings. European shafts are generally circular, about twenty feet in diameter, and where the rock is moderately dry they are lined with brick excluding the water that may occur in the fissures. As the shafts are sunk, and at intervals of about seventy-five feet, iron curb rings are placed as follows:

A cast iron ring made of sections bolted together with a groove or gutter on the inside (See Fig. 1) is placed in a notch cut in the rock. With this curb as a foundation the brick lining is built up to the ring above. As a rule the brickwork is built from a staging or platform suspended in the shaft in such a way that the sinking

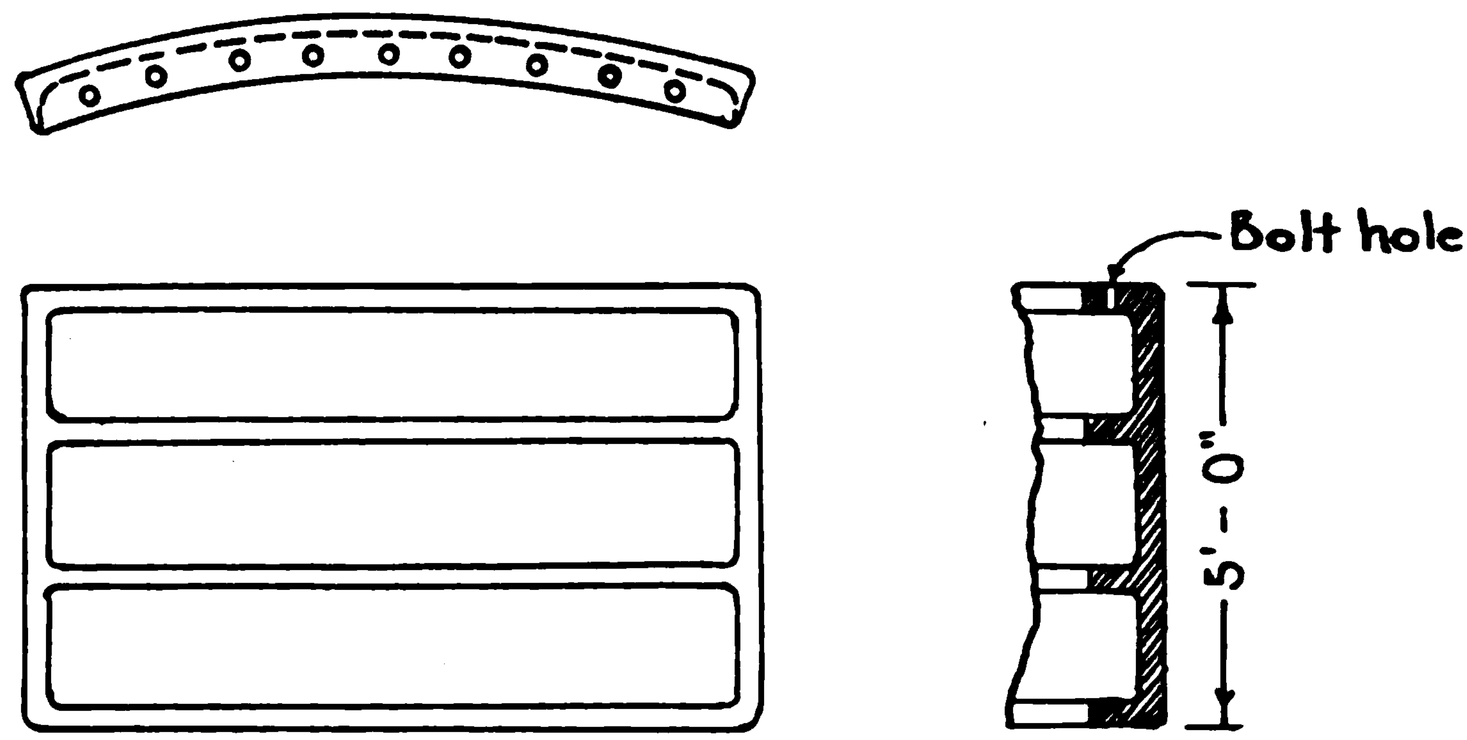

FIG. 2.

bucket can go up and down without interference. The lining is placed rapidly, as many as 3,000 bricks a day being laid by one man. The water that comes in through various seams in the rock is drained through passages in the curb ring to the gutter and conducted thence to a pipe in the shaft running down to the pump.

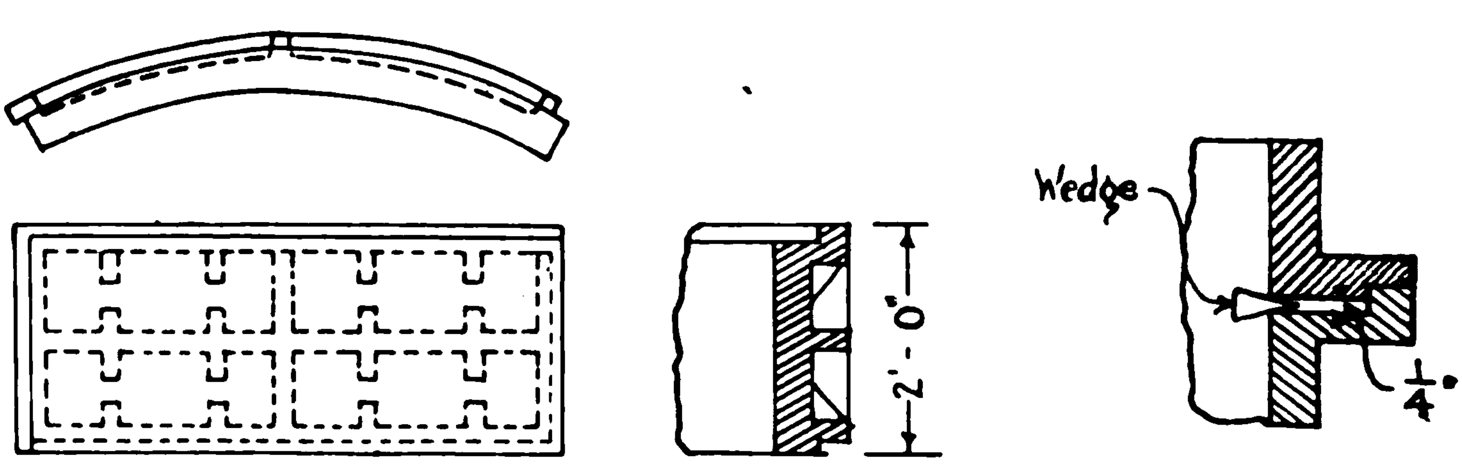

FIG. 3.

The interior of the shaft is thus made absolutely dry and none of the water can fall into the shaft and interfere with the operation of the cages.

Where the rock is very wet the Europeans do not believe in pumping and keeping 3,000 or 4,000 horse power in boilers to run pumps, so they use a shaft lining made of cast iron plates—some-

had to build a strong bulkhead so that grouting would be possible. We stuck a pipe into the fissure at the bottom of the cut and drained the water through it, then built a bulkhead of concrete 8 feet thick across the entire face of the heading. The bulkhead was heavily reinforced by rails set into holes drilled in the ribs. We provided additional grout pipes through the bulkhead after the concrete had set for a week, grouted all pipes at pressures up to 1,000 pounds per square inch, completely cutting off the water. When driving was resumed no water was encountered.

MR. FURBER.—That grouting was sufficient to fill up the fissures, was it?

MR. DONALDSON.—Yes, we put in about three carloads of cement.

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builders at 89 B. H. P. when operating at 290 revolutions per minute.

Engines as installed are actually operated at 265 revolutions, with proportionate loss of power.

Pumps.

Each engine has its crank shaft extended and direct-connected by flanged coupling to the pinion shaft of 13″ diameter by 15″ stroke, single acting, triplex Deane pump. To accommodate the alignment of engine and pump shafts the pumps are set in a pit about three feet deep. Each pump is fitted with a single reduction of gears of 6 to 1 ratio, and when running at 44.1 revolutions, has a capacity of 1,640,000 gallons per 24 hours. Each pump is fitted with large suction and discharge air chambers, relief valves and starting valves.

Auxiliaries.

Each engine drives a small belted air compressor for compressing air to a pressure of 250 pounds gauge. This compressed air is stored in a battery of three air tanks and is used to start the engine. In addition to these compressors a small gasoline driven air compressor was installed lest the compressed air storage be lost by accident or leakage. It may be of interest to state that no difficulty has been found in retaining air charges for a week at a time and ordinarily one charging is sufficient to make a half dozen starts. Of course, engines are started without load by opening starting valves on pumps.

Each engine is equipped with ½ kilowatt 110 volt generator and 6 cell Edison battery with necessary spark coil, resistance lamps, combination switchboard and fuse blocks for electric ignition.

Suction Discharge Piping Air Chambers.

Each pump has an independent suction pipe to suction well, and discharges through a 16″ connection to the 16″ main discharge pipe.

As the discharge takes place at times through a main 15 miles long, it was thought best to install a large steel air chamber at the back end of discharge main. This air chamber is 60″ in diameter by 12 feet high, and is charged with air from small air compressors used for starting engines.

Steel air chambers, suction and discharge piping complete, including all auxiliaries not included in above..	4,500.00
Filters complete	13,750.00
Total cost of mechanical plant, building and lands	$77,250.00
Total cost of mechanical plant, building and lands, exclusive of filters	63,500.00
Cost of plant per B. H. P. as at present installed 162 B. H. P., exclusive of cost of filters	392.00
Cost of plant exclusive of filters per million gallon capacity per 24 hours	19,250.00

Fuel Used and Cost.

A good grade of anthracite pea coal is used, costing $2.75 per ton of 2,240 pounds at the mine. The freight from mines to Bear is $1.70, to which must be added the cost of hauling, amounting to 65 cents per ton, making the total cost of coal delivered in coal storage bins $5.10 per long ton.

It might be well to state here that it does not pay to purchase anything but the best grade of white ash non-clinkering coal, which must also be of a uniform grade as to size.

Performance Test.

The guaranteed test conditions were as follows:

When operating engines at 89 B. H. P. the consumption of coal was not to exceed 1.3 pounds per B. H. P. hour, and when operating the engines at 45 B. H. P. the guaranteed coal consumption was not to exceed these guarantees, the full load test being 1.02 pounds of coal per B. H. P. hour and 1¼ pounds per delivered water horsepower, equivalent to a duty per hundredweight of coal of 158,400-000.

We will for the present drop the gas producer plant and give our attention to the steam plant with which it is being compared.

Octoraro Water Company Plant.

This company was organized about 1903, and, as its name implies, obtains its water supply from the Octoraro Creek. There are two pumping stations, the first or steam statio we have to deal, located about three miles south on the west branch of Octoraro Creek; the other pumping station located below the junction of the forks at Pine Grove Forge, Pa.

Complete mechanical plant including boilers, engines, auxiliaries, steam and water piping, covering, etc....	39,850.00
Total cost of mechanical plant....................	\$77,725.00

This latter figure should be compared with the cost of the Delaware plant exclusive of filters, i. e., \$63,500.00.

Cost of plant per B. H. P. of engine, allowing 10% for friction of engine.............................	190.00
Cost of plant based upon total capacity in million gallons per day..............................	12,100.00

Fuel Used and Cost.

The best grade of "B" or Miller vein bituminous coal from the South Fork region is used, costing \$1.50 per ton of 2240 pounds at the mines. The freight from the mines to Quarryville is \$1.50 per ton, to which must be added the cost of hauling, amounting to \$1.40 per ton, making the total cost of the fuel delivered in coal storage bin \$4.40 per ton. This coal is high in carbon, low in volatile matter and is one of the best steaming coals mined in Pennsylvania.

Performance Test.

The duty guarantee was to be not less than 100,000,000 foot pounds per thousand pounds of dry steam when operating at a capacity of 3,000,000 gallons per 24 hours against a working water pressure of 332 to 362 feet; the steam pressure, 135 pounds at the throttle. The steam consumption of the independent air pump is to be included with that used by main engine.

We have gone rather fully into the description of these plants, chiefly to give a clear idea of the two plants, so that individual conclusions may be made upon the matter to follow.

Operating Records, Expenses, etc.

As before stated, complete daily records of operating conditions were kept at pumping station. The more important and pertinent ones for this paper are:

1st. Fuel consumed.

2nd. Daily pumpage in gallons by meter.

3rd. Total pumping head, which included, 1st, suction head, 2nd, discharge head. (Plus or minus correction for difference in elevation of gauges. This was a constant, as gauges were permanent.

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Complete mechanical plant including boilers, engin auxiliaries, steam and water piping, covering, etc . .

Total cost of mechanical plant . . . .

This latter figure should be compared with the cost of exclusive of filters, i. e., $63,500.00.

Cost of plant per B. H. P. of engine, allowing 10% f friction of engine . . . .

Cost of plant based upon total capacity in milli gallons per day . . . .

Fuel Used and Cost.

The best grade of "B" or Miller vein bitumin South Fork region is used, costing $1.50 per to at the mines. The freight from the mines to Qu per ton, to which must be added the cost of hauli $1.40 per ton, making the total cost of the fuel storage bin $4.40 per ton. This coal is high in ca tile matter and is one of the best steaming coals vania.

Performance Test.

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Superintendence.

Under this heading is included not only the salary of the superintendent, but that of his office assistance, stationery, postage, telegraph, telephone, office rent, livery and other incidental expenses. The superintendent must necessarily be a high grade man, for the success of the plant depends upon him.

The superintendent's salary we have placed at	$2,500	per	year.
A bookkeeper and clerk at	1,200	"	"
A stenographer at	500	"	"
Office rent, including heat, light, water, etc.	300	"	"
Postage	100	"	"
Telephone and telegraph	170	"	"
Stationery	250	"	"
Livery and miscellaneous expenses	500	"	"
Making a total of	$5,520	"	"
Of which amount we have charged 16 1-3% to the mechanical plant, amounting to	$ 920	"	"

Depreciation.

Here we have only to consider the mechanical plant and its housing. For the Corliss engine plant we have figured upon an average life of 20 years for the mechanical plant, and 35 years for buildings, etc. For the gas producer plant, we have allowed an average life of only 15 years for mechanical plant and 35 years for buildings. Our reason for allowing only 15 years for the gas engine plant is that we have not had sufficient experience with this class of machinery to warrant our giving it a longer life, although w can see no reason why its life should not equal that of a steam driven plant.

We therefore set aside at the end of each year a sum which at 4% compound interest will at the expiration of the life of the plant amount to its first cost,

This sum is

1st Delaware Plant.

For mechanical plant excluding filters	$ 1,236.00
For building	458.00
Total each year	$ 1,694.00

2nd Octoraro Plant.

For mechanical plant	1,340.00
For buildings	447.00
Total each year	$ 1,787.00

It will be noted that no depreciation is allowed for obsolescence, inadequacy or supersession.

Sinking Fund for Retiring Bonded Debt.

We are of the opinion that this item should not be included in the cost of operating a public utility, for the reason that capital should be everlasting; nevertheless, the courts of our country allow it, and, furthermore, we have seen, time and again, private water, gas and electric light companies' plants virtually confiscated by the public through the instrumentality of completing plants paralleling the lines and mains of the older company, so a sinking fund is imperative or no company could dispose of its bonds. This sinking fund we have figured upon a 4% basis, 30 year life of bonds—and amounts to $1,043.00 for the Delaware Company plant and $1,297.00 for the Octoraro plant.

Interest.

We will issue bonds having a rate of interest sufficient to cause them to sell at par. This interest we have taken at 7%, as this would seem to be about the rate of interest this class of investments should bear, where the plants are well established in a growing territory. This annual charge amounts to $4,095 for the Delaware plant and $6,491 for the Octoraro plant.

Insurance.

This item covers fire liability and boiler insurance. The buildings of both plants are substantially built of non-burning material, except for windows doors, and roof, and could therefore be but little damaged by fire. The machinery would however be subject to considerable damage. We have therefore, for insurance purposes, placed a valuation of $20,000 on the Delaware plant and $30,000 on the Octoraro or steam plant. Both plants are fully equipped with fire fighting apparatus and thereby receive the benefit of the lowest insurance rates for isolated plants. This amounts to $66 per year for the Delaware plant and $90 per year for the Octoraro

plant. The boiler and liability insurance we have taken at $160 per year for the Octoraro plant. The Delaware plant has no boiler plant and therefore only liability insurance is carried. This costs $10 per year for $10,000 insurance. We have, therefore, a total insurance charge of $76 for the Delaware plant and $250 for the Octoraro plant.

Taxes.

The state levies a bond tax of four-tenths of one per cent. on all bonds, and five-tenths of one per cent. on the value of the stock as assessed by the State. As before stated, the stock has only a nominal value of $10 per share, and for the purposes of taxation we will assume that the same amount of stock as bonds is issued. This would be the equivalent of a tax of 45-100 of one per cent. on the bond issue alone and would amout to

For the Delaware plant, $263.00 per annum.

For the Octoraro plant, $327.00 per annum.

Grouping the above items into a table we have thefollowing:

TABLE I.

Item.	*Delaware Plant.*	*Octoraro Plant.*
Management	$ 200.00	$ 200.00
Superintendence	920.00	920.00
Depreciation	1,694.00	1,987.00
Sinking Fund	1,043.00	1,297.00
Interest	4,095.00	6,491.00
Insurance	76.00	250.00
Taxes	263.00	327.00

or grand totals of .... $8,291.00 per annum
for the Delaware plant, and $11,472.00
for the Octoraro plant.

Operating Expenses.

Below is given a table of operating expenses of the two plants. For ease of comparison each year for both plants is placed in adjoining columns.

Table II.

Operating Charges.

Delaware Water Co., Gas Plant. Octoraro Water Co., Steam Plant.

ITEM.	1908		1909		1910		1911		1912	
	Plant		Plant		Plant		Plant		Plant	
	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam
....	609.22	3497.78	641.51	3953.50	1173.58	4098.81	1474.40	4167.30	1796.35	4418.07
aste and Packing	180.62	182.38	195.58	168.90	333.33	128.98	227.57	201.88	200.64	202.70
ng and Machinery Repairs	100.64	108.88	*280.07	14.00	†418.73	245.97	251.06	542.87	‡416.19	603.83
ng Station Wages	1501.67	2529.60	1853.06	2412.15	2276.03	2309.88	2518.27	2180.00	2507.89	2382.82
laneous Expenses.........	75.09	192.59	133.75	107.09	143.18	81.11	183.90	146.03	274.81	197.30
otal per Annum ...	2367.26	6506.18	3103.97	6655.64	4344.85	6864.80	4655.2	7238.81	5195.88	7804.72

ncludes the replacing of spiral riveted purge pipes on producers, with cast iron pipe.
ncludes spare parts for engines, such as inlet and exhaust valves, piston rings and piston, etc.
ncludes compromise settlement of claim for damaged castings that developed in producer in 1908, be-
e plant was finally accepted.

Combining Tables I and II we obtain Table III, which gives the total combined operating and fixed charges for each of the plants:

Table III.

Combined Fixed and Operating Charges.

Delaware Water Co., Gas Plant. Octoraro Water Co., Steam Plant.

ITEM.	1908		1909		1910		1911		1912	
	Plant		Plant		Plant		Plant		Plant	
	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam
ting Expenses............	2367.26	6506.18	3103.97	6655.64	4344.85	6864.80	4655.20	7238.81	5195.88	7804.72
and Overhead Charges....	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00
otal Yearly Cost.........	10658.26	17978.18	11394.97	18127.64	12635.85	18710.81	12746.20	18710.81	13486.88	19276.72

Mechanical Performance of Plant.

We have tabulated the principal items of the daily log records of the plant for each month, showing the average results for each year and for the total period of five years. This record is shown in Table IV, and, as a further aid and to show the monthly variations in operation, we have plotted them as a diagram.

Table No. IV.

Summary of Pumping Station Daily Record Sheets

Delaware Water Company, Christiana, Del. *Octoraro Water Company, Quarryville, Pa.*

Economical Results.

From the information obtained and shown in Tables I, II and III, we have prepared Table V, which gives the cost of pumping one million gallons of water, one hundred feet high.

TABLE V.

COST OF PUMPING ONE MILLION GALLONS 100 FT. HIGH.

OVERHEAD, FIXED AND OPERATING CHARGES.

Delaware Water Co's, Gas Engine Plant.	*Octoraro Water Co's., Steam Engine Plant.*

Line 15 gives the combined total cost.

The cost per million gallons for items, Lines 1 to 7 inclusive of fixed charges, and Line 11 of operating charges, was obtained by dividing the annual cost for that item by the actual number of million gallons pumped for the year, as these charges were independent of the pumping head. Items 9, 10, 12 and 13 were obtained by dividing the annual cost by the equivalent million gallons pumped one hundred feet high for year.

Lines 16 and 17 show the average cost per million gallons for the five year period, \$28.36 for the gas plant and \$32.95 for the steam plant.

This is equivalent to \$56.80 and \$68.50 per horsepower for 24 hour power delivered to the customer, or, stated another way, it is equivalent to .88 and 1.05 cents per kilowatt for the steam and gas plants respectively.

In conclusion it may be stated that the figures given are the actual results obtained in two existing plants similarly situated and therefore comparable.

Necessarily, the local conditions, nature and cost of fuel available, etc., must enter into every discussion as to the kind of power to be adopted for a proposed plant, but it is our opinion that the gas engine driven pumping engine has a much wider field than has heretofore been accorded it.

We wish to thank those who in their official capacity have permitted the use of the data that has made this paper possible.

DISCUSSION.

Mr. Ledoux.—It will be noted that the steam plant referred to by Mr. Gibson ran on the average about half of the 24 hours, while the gas plant generally ran the entire 24 hours. The comparison in favor of the gas plant may be assumed by many as due to this fact. However, the average duty of that particular steam plant amounted to about 66,000,000, which is about as high as is obtained in other similar plants where the run is continuous. This high duty is evidently due to the good fuel, good management and excellent handling of the plant. About 70,000,000 annual duty is in my judgment the upper limit of a plant of that kind.

Prof. Fernald.—I am not prepared to discuss the paper in detail, but I am very much interested in the statements of fuel efficiency and the operation of the plants. I have been following producer gas problems for some time, and have been pleased to see how the problem has worked out in favor of the gas plant under actual operating conditions.

There is one feature, however, I would like to call attention to. In this particular installation we find very high grade coal being used. In a plant that is operating under rather ideal conditions for producer gas work, that is, under uniform load, the producer gas plant makes good. What those of us who are interested in producer gas would like to see is the utilization of grades of fuel that can not be used to good advantage in steam plants. Not only have producer gas planst made good on high grades fuels, but it has been demonstrated that low grade fuels can be utilized to good advantage. I hope this organization may have reports of plants which have been operating on grades of fuel that are not advantageous in ordinary steam plants, because that is a field of great importance as far as our fuel conservation is concerned, and the time is coming when we will

The plant consists of one 17 x 27½ De La Vergne type "FH" twin cylinder oil engine—180 brake horsepower rated capacity, direct connected to a 125 K. W. 525 volt D. C. generator; the electric current generated being utilized to drive motors and for lighting purposes.

Actual Cost of Power.

Plant operated 588 days or 5985.30 hours total:
Total K. W. hours produced 369,684—552,217 brake horsepower hours by calculation.
Load Factor—54.2%

	Total	Per K. W. Hr.	Per B. H. P. Hr.
Fuel Oil 38,211 gallons	$859.75	$.00232	$.00155
Lubrication	228.72	.00061	.00041
Miscellaneous	123.20	.00032	.00022
Labor and attendance	1361.42	.00368	.00246
	$2573.09	$.00693	$.00464

Fuel oil employed 28.8° Beaume = 7.35 pounds per gallon.
Pounds of oil used—.761 per K.W. hour—*.508 per horsepower hour.*

The point I wish to bring out is this:

This 180 HP. type "F. H." De La Vergne oil engine was guaranteed to develop its power at the following load of fuel consumption:

Full load	0.5	pound per B. H. P. Hr.
¾ "	0.5	" " "
½ "	0.55	" " "

The engine operated at an average load of 54.2% for a period of two years and during that time the total oil consumption was 38,211 gallons which is at the rate of 0.508 pounds per brake horsepower hour. It is true in the general case that the operating results with an oil engine are identical with the test results.

The next slide shows a longitudinal section of a De La Vergne type "FH" engine, which is the type adapted to burn Mexican crude oil and tars. The difference between this engine and the Diesel type is that the compression pressure is carried only to 280 pounds instead of 525 and at the end of the compression stroke the oil is atomized by compressed air into the vaporizer chamber shown by the circle at "D". In order to work with the greatest economy it is necessary

Fig. 2.
Longitudinal Section of Engine.

to burn the cheap Mexican crude oils, and to do this the vaporizer chamber must be used. It is not necessary to treat this vaporizer with the same degree of respect as one would the cylinder walls in the case of the Diesel type of engine, where the oil is injected directly into the cylinder. We have had no trouble whatever in burning not only Mexican crude oil, but also water gas tar and coke oven tar without carbonization of any kind.

W. J. WARNER

Mr. Walter J. Warner, Associate Member of the Engineers' Club, formerly connected with W. S. P. Shields, died suddenly on June 10th, 1913.

R. A. SHILLINGFORD.

Mr. Shillingford was born in Philadelphia in 1857; a graduate of the University of Pennsylvania in 1879 and afterwards connected with the Cambria Steel Company of Johnstown, Pa., and later with the Berwind White Coal Mining Company as Mine Engineer. In 1887 he became Superintendent of the Clearfield Bituminous Coal Corporation at Peale, Pa., and in 1900 removed to Clearfield, Pa. In 1909 he was made Vice President and General Manager of the Clearfield Bituminous Coal Corporation. At the time of his death he also held the position as Inspector of coal properties of the N. Y. C. & H. R. R. R. He was Director of the Beech Creek Railroad, and of the Clearfield & Franklin R. R. He was also a Director of the Clearfield Trust Company, and later was Vice President of that institution, and at the time of his death was President. He was Vice President of the Clymer Electric Company, and Director of the State Central Electric Company. He was a Director of the Kittanning Coal Company of Philadelphia, Empire Coal Mining Company of Philadelphia and Pioneer Coal Company of Philadelphia. In 1908, he was a member of the Commission appointed by the Governor of Pennsylvania, to revise the mining laws of this state. He was a member of the University Club of Philadelphia, Engineers' Club of Philadelphia and Pennsylvania Society of New York.

Mr. Shillingford died Monday, June 16, 1913.

PAPERS SCHEDULED FOR THE FALL TERM

The Meetings Committee beg to announce that the following papers have been scheduled for the fall term:

September 20—SEWAGE TREATMENT IN PENNSYLVANIA.
By Charles F. Mebus, Vice President, Engineers' Club.

October 4—THE LIMITATIONS OF MATHEMATICAL THEORY APPLIED TO ENGINEERING.
By W. G. Button, Engineer, Bureau of Building Inspection, Philadelphia.

October 18—MODERN COLOR PHOTOGRAPHY.
By Henry Leffmann, Past President, Engineers' Club.

November 1—HOUSING AND SANITATION.
By Bernard J. Newman, Secy., Phila. Housing Commission.

November 15—THE GRAND CENTRAL TERMINAL IMPROVEMENTS.
By George A. Harwood, Chief Engineer, N. Y. C. & H. R. Railroad.

December 6—THE HUDSON RIVER SIPHON.
By Ralph N. Wheeler, Division Engineer, Board of Water Supply, New York.

December 20—CONCRETE ROADWAYS.
By Lewis R. Ferguson, Asst. Secy., Amer. Portland Cement Manufacturers.

January 3—THE SCRANTON MINE PROBLEM.
By Eli T. Conner, Consulting Mining Engineer.

January 17—SOME RECENT IMPROVEMENTS IN STEAM LOCOMOTIVES.
By George R. Henderson, Consulting Engineer, Baldwin Locomotive Works.

February 7—ANNUAL MEETING.—Presidential Address.

ADDITIONS TO THE LIBRARY

The following books have been presented to the library of the Engineers' Club by the Junior Section:—

Technological Dictionary (3 vols.)—*Tolhausen.*
Municipal Franchises—*Wilcox.*
Engineering Valuation of Public Utilities—*Foster.*
The Law of Operation—*Wait.*
Valuation of Public Service Corporations—*Whitten.*
Logarithms—*Bruhns.*
Advanced Algebra—*Milne.*
Plane and Solid Geometry—*Milne.*
Evolution of Internal Combustion Engines—*Butler.*
Applied Mechanics—*Rankin.*
Treatise on Hydraulics—*Merriman.*
Fire Prevention and Fire Protection—*Freitag.*
Principles of Concrete Construction—*Turneaure and Maurer.*
Field Engineering—*Searles.*
Cost Data—*Gillette.*
Engineering Work in Towns and Cities—*McCullough.*
Tunneling—*Prelini.*
Plane Surveying—*Tracy.*
Mechanics Applied to Engineering—*Goodman.*
Theory of Structures—*Spofford.*
American Civil Engineers' Pocketbook.
Engineering Index Annual—1912.
Principles of Electrical Engineering—*Pender.*
Electric Power Transmission—*Bell.*
The Art of Illumination—*Bell.*
Centrifugal Pumping Machinery—*De Laval.*
Mill Buildings—*Ketchum.*
Street Paving and Paving Material—*Tillson.*
American Highway Assoc. Good Roads Year Book—1913.
Freight Terminals and Trains—*Droege.*
Treatise on Roads and Pavements—*Baker.*
Dust Preventives and Road Binders—*Hubbard.*
Art of Roadmaking—*Frost.*
Modern Asphalt Pavements—*Richardson.*
Construction of Dams—*Wegmann.*
Reservoirs—*Schuyler.*
Central Station Heating—*Gifford.*
Practical Manual of Steam and Hot Water Heating—*Pierce.*

Sewage Disposal—*Fuller*.
Public Water Supplies—*Turneaure and Russell*.
Sewer Construction—*Ogden*.
Sewerage—*Fowell*.
Water Power—*Frizell*.
Journal Royal Institution of British Architects—1910.
Town Planning in Practice—*Unwin*.
Concrete and Steel Construction—*Morsch*.
Principles of Wireless Telegraphy—*Pierce*.
Chemiker Kalendar.
Explosives—*Brunswig*.
Portland Cement—*Butler*.
Corrosisn and Preservation of Iron and Steel—*Cushman and Gardner*.
Concrete Costs—*Taylor and Thompson*.
Walls, Bins and Grain Elevators—*Ketchum*.
Concrete, Plain and Reinforced—*Taylor and Thompson*.
Masonry Construction—*Baker*.
Architectural Engineering—*Freitag*.
Commercial and Library Atlas of the World—*Hammond*.
Paints and Varnishes—*Sabin*.

SOME LOCAL TRANSPORTATION STATISTICS

MILES OF TRACK IN PHILADELPHIA.

Pennsylvania R. R.	502.2
B. & O.	70.0
Phila. & Reading Railway	*132.76
Phila. Rapid Transit Company	660.0

PASSENGER TRAINS PER DAY

	Inbound	Outbound
Pennsylvania R. R.	†580	†580
B. & O.	21	21
Phila. & Reading Railway	229	234

FREIGHT TRAINS AND TONNAGE

	Inbound		Outbound	
	Cars	*Tons*	*Cars*	*Tons*
Pennsylvania R. R.	658	11,514	749	10,526
B. & O.	†15	11,000	‡12	6,000
Phila. & Reading Railway	‡79		‡81	

The Philadelphia Rapid Transit Company operate approximately 2000 surface and 165 elevated cars; and 6660 miles of track.

* There are in addition 215.81 miles of sidings in the city of Philadelphia.

† This is the daily average and does not include 45 trains passing through West Philadelphia which do not enter Broad Street Station.

‡ Trains.

ABSTRACT OF MINUTES OF THE CLUB

BUSINESS MEETING, June 7, 1913.—The meeting was called to order by President Taylor at 8:35 P. M., with 57 members and visitors in attendance.

The minutes of the meeting of May 17th, 1913 were approved as printed in abstract.

Following the report of the Tellers, the President declared that the amendments submitted to the Club were carried and would be incorporated in the By-Laws.

The Committee on Nominations, consisting of H. E. Ehlers, Chairman, Joseph C. Wagner, F. H. Stier, Carl Hering, E. M. Nichols, Thomas C. McBride and George T. Gwilliam, appointed by the Board of Governors at their meeting of May 15th, was accepted.

Mr. D. Robert Yarnall presented the paper of the evening, entitled, "Scientific Management Applied to the Design and Management of a Modern Valve Plant," which was discussed by Messrs. John C. Trautwine, Jr., E. M. Nichols and J. E. Gibson.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS

Special Meeting, June 19, 1913.—The meeting was called to order at 8:10 P. M. Present, President Taylor, Vice Presidents Plack and Swaab, Directors Vogleson, Haldeman, Gibson, Worley, the Secretary and the Treasurer.

The Treasurer reported a net gain of $1929.19, as compared with $27.14 for the same period of last year.

The Treasurer was instructed to strike the names of William G. Bickell and F. K. Wilkinson from the roll as of July 1, 1913, for nonpayment of dues, and to charge off their dues from the books.

Reports of the Finance and House Committees were read and approved.

The report of the Membership Committee was read, and, in accordance with the recommendations of the Committee, the following were elected:

Active: William C. Greany, Crosby Miller. Associate: A. Morris Herkness, James F. McCrudden.

The death of Walter J. Warner was announced, and the Treasurer instructed to charge his dues off the books.

The question of rearranging the accounts and the appropriation schedule was referred to the Treasurer and Chairman of the Finance Committee, with power to act.

The President and Treasurer were authorized to enter into an agreement with the Business Manager, in which the payment of the bonus due the Business Manager be deferred until the annual audit of the books.

The report of the Business Manager was read and approved.

INDEX VOLUME XXX

THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

OFFICERS FOR 1913

President
W. PURVES TAYLOR

Vice-Presidents

Term Expires 1913
W. L. PLACK

Term Expires 1914
CHARLES F. MEBUS

Term Expires 1915
S. M. SWAAB

Secretary
EDW. E. KRAUSS

Treasurer
J. REESE BAILEY

Directors

Term Expires 1914	*Term Expires 1915*	*Term Expires 1916*
R. G. DEVELIN	H. C. BERRY	J. E. GIBSON
RICHARD GILPIN	B. A. HALDEMAN	H. CLYDE SNOOK
J. A. VOGLESON	S. M. SWAAB	MORTON E. HIBBS
HENRY HESS	D. ROBERT YARNALL	J. FRANK WORLEY

Trustees of the Bond Redemption Fund

HENRY LEFFMANN, Chairman — EDGAR MARBURG — EDWIN F. SMITH

STANDING COMMITTEES

House—F. K. WORLEY, W. L. PLACK, J. A. VOGLESON, G. F. PAWLING, H. A. MOORE.

Meetings—S. M. SWAAB, B. A. HALDEMAN, D. R. YARNALL, J. B. MCCORD, W. C. FURBER.

Membership—CHAS. F. MEBUS, R. G. DEVELIN, H. C. SNOOK, H. H. QUIMBY, W. P. DALLETT.

Finance—J. A. VOGLESON, CHAS. F. MEBUS, S. M. SWAAB, HENRY HESS, J. M. DODGE.

Publication—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

Library—B. A. HALDEMAN, H. C. BERRY, W. C. FURBER, F. N. MORTON, A. L. MAGITLON.

Publicity—J. R. BAILEY, D. R. YARNALL, F. K. WORLEY, G. T. GWILLIAM, H. B. ALLEN.

Advertising—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

MEETINGS

Annual Meeting—1st Saturday of February, at 8:15 P. M.

Stated Meetings—1st and 3d Saturdays of each month, at 8:15 P. M., except between the fourteenth days of June and September.

Business Meetings—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.